NATIONAL SCIENCE FOUNDATION AUTHORIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

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COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

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NATIONAL SCIENCE FOUNDATION AUTHORIZATION

THURSDAY, MARCH 25, 1982

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C.

The subcommittee met at 9:38 a.m. in room 235 of the Russell Senate Office Building , Hon. Harrison H. Schmitt (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. Good morning, ladies and gentlemen.

A year ago this subcommittee conducted its first authorization hearings for the National Science Foundation as part of a gradual program of providing the Senate with a single point of integrated examination of the science and technology activities of the Federal Government and how they relate to other activities outside the Federal Government.

Much has happened in the year since those hearings. Public awareness of the importance of science and technology has grown, and a number of imaginative initiatives have emerged. We see even today a very strong interest in the news media as well as among the public in the ongoing flight, the third flight of the space and air ship *Columbia*, which I am happy to say will soon return safely to Earth at the space harbor at White Sands, N. Mex. This is the first, I believe, of a long line of space-related activities in that area of New Mexico, to join the already extensive science and technology activities in that State.

Some States, such as New York and Michigan, have taken significant steps, in concert with their industries and universities, to develop selected major new scientific and technological capabilities. The New Mexico State Legislature, as another example, is continuing to support its intrastate solar energy research activities and geothermal activities.

The New Mexico State University, by the way, is going to dedicate its geothermal heating system in the next few weeks. They will have at the time of dedication 30 buildings tied into a geothermal heating system and do not anticipate ever building another building on that campus that is not heated by geothermal energy.

Last fall in the State of New Mexico we had a major showcase for technology involving the demonstration of the science and technology activities of the Federal laboratories and universities of the

State. Over $1 billion a year worth of such investment was showcased for the industrial community of the State and the nation. It was a very successful activity, far more successful than we had anticipated.

A number of private industries have announced several innovative programs to support academic research in education in universities. More and more Governors, legislatures and local governments are raising questions about the quality and extent of precollege education in science and technology.

In a recent meeting, the first annual meeting, we hope, of the President's Transition Science and Technology Advisory Group, it was clear that there is increasing concern and commitment within the private sector toward improving the climate for science and technology education.

These developments indicate a spreading recognition that building this Nation's scientific and technological capabilities is a truly national responsibility shared by localities, State governments, private businesses, industries and the Federal Government. The Federal role, is essential and supportive, need not be preemptive, even though clearly more is required than is currently under way.

At the same time, the challenges to our scientific and technological superiority remain ominous. The clouds on the horizon are extraordinarily dark. No condition is more disturbing than that of our science and technology manpower decline, as witnessed by the woefully inadequate pool of precollege science and mathematics teachers; the nearly 2000 engineering faculty positions which are going unfilled because of the absence of interested, qualified candidates at salaries that the university and college system can afford to pay; the very limited science and mathematics education received by our precollege students compared to that of any other industrial country and compared even to that of the 1960's in this country; the near absence of a national training capability for skilled craftsmen and technicians; and the continued decline of the extraordinary programs that the National Science Foundation put in place in the early 1960's in response to the sputnik challenge from the Soviet Union.

In addressing these national challenges, the National Science Foundation has a unique position. Unlike other Federal agencies which support research directed at legislated missions, the NSF is charged with the overall health of science, particularly basic research in science and engineering.

Most of that research is in turn conducted through grants and contracts to the nearly 2,000 colleges and universities where our future discoverers and inventors are trained and educated.

This year the Subcommittee on Science, Technology, and Space is planning 2 days of hearings on the National Science Foundation. We plan to hear from a number of nonagency witnesses on April 21, but today we will hear testimony from Dr. John B. Slaughter, Director of the National Science Foundation, Dr. Donald Langenberg, Deputy Director of the NSF, and, if fog permits, Dr. Lewis Branscomb, Chairman of the National Science Board.

They will highlight, I hope, the proposed 1983 program changes in the science and engineering directorates, initiatives in science and engineering education, research instrumentation needs in uni-

versities, and private sector responses to meeting the need for academic research project support, instrumentation and student aid.

Gentlemen, let me welcome you to this hearing, and as we take your testimony, I am sure there will be some questions. I will not get through them all, so we will have some other questions for the record.

If you could summarize your oral presentation, we will certainly make your longer written testimony a part of our record and allow you to submit any supplemental information you may decide is important.

Dr. Slaughter, again, welcome to the subcommittee. It is exciting to have you with us. As near as I can tell from all the comments, as well as my own observations, you are doing an outstanding, and much appreciated job under somewhat difficult circumstances.

STATEMENT OF DR. JOHN B. SLAUGHTER, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. SLAUGHTER. Thank you very much, Senator Schmitt. It is a pleasure for us to be here before you this morning. I thank you for your kind words and your opening remarks, which I thought set the stage very well for the things that we will attempt to explore with you this morning.

Your committee, and you, in particular, have done an exceptional job, particularly in looking at last year's activities in supporting the Foundation very strongly and giving us a base upon which we can proceed in our fiscal year 1983 and subsequent budgets.

I wanted to make a comment concerning your opening remarks about the showcase for technology. I was very pleased to have been invited to participate in that.

Senator SCHMITT. We certainly enjoyed having you. The comments in New Mexico and the international community that was present were extraordinarily positive about your contribution.

Dr. SLAUGHTER. New Mexico was a very large, hospitable place for us in those days.

Senator SCHMITT. I hope your intestines survived.

Dr. SLAUGHTER. They did. I received good training in that part of the country before, so I was prepared for it. There was a glittering array of products from the State of New Mexico, and it was certainly a very pleasant experience and a good opportunity to see what is being accomplished there.

Senator SCHMITT. You might be interested to know that we are following up that conference this September, the week of the 13th or 14th, with a different theme. In this case we are providing an opportunity for the small- and medium-sized businesses with small- and medium-level technology products to demonstrate and articulate their wares to the larger national contracting community, both public and private, as again a new concept in technology exchange. It is, I think, going to move along very well. So far the response is very positive.

Dr. SLAUGHTER. That is very good. I am very pleased to hear that. We have at the Foundation a great deal of interest in New Mexico, of course, because of our investments in the astronomy facilities there and the activities underway at both the University

of New Mexico and New Mexico State in the resource center, and we are very, very pleased to be participants.

This morning, Senator Schmitt, I will summarize my statement which has been submitted to you and try to hit the highlights of several activities which we feel to be important. As you indicated, Dr. Lewis N. Branscomb, who is chairman of the National Science Board, is somewhere on the continuum between White Plains and Washington, and hopefully will appear to give his testimony before the end of the time allotted to us.

Senator SCHMITT. It is my understanding that he is not going to be able to make it. We just received that word. We will certainly give him an opportunity to testify at our next meeting.

Dr. SLAUGHTER. We will submit his testimony, then, for the record, with your permission.

Don Langenberg and I, then, will share the presentation this morning, and I will make some broader comments concerning the Foundation's program, and Don will focus on some activities of instrumentation which are important. We have some of our senior staff here to answer any specific questions related to areas that may interest you.

The Foundation's budget in fiscal 1983, Mr. Chairman, shows an increase of about $76.6 million over fiscal year 1982 overall request. The budget at that level would be $1,072.8 million. Most of that represents an increase in research in related activities, and if you look at the percentage increase, the $71 million increase in research shows about a $7.3 million increase over the equivalent figures in fiscal year 1982.

This increase does provide us with an opportunity for some real growth in some important areas of the Foundation's program. We believe that when one recognizes the seriousness of the economic situation in which we find ourselves, the Foundation's budget is, in fact, a strong indication of the importance attached to scientific and technological activities in this country, and we are very pleased to be bringing this budget before you for your examination.

In fiscal year 1983 the Federal Government is going to make an investment of about $5.8 billion in the support of basic research. The Foundation's portion of that is approximately 17 percent of the total Federal obligations.

As you indicated in your opening remarks, NSF alone has the unique responsibility of being chartered for the purpose of promoting the progress of science in all areas of science, the physical, the biological, the life, behavioral, and social sciences.

Senator SCHMITT. Doctor, if I could interrupt briefly, do you feel that the experiment that was made in having the NSF try to undertake mission-related activities in the early 1970's has proved to be a successful experiment, or do you think we are better off concentrating, as we seem to be now, on NSF's being an agency for the support of basic engineering and science activities?

Dr. SLAUGHTER. I think the latter approach is the right one, Senator. I think, on the other hand, that we learned some things we would not have learned had we not done that; that in fact the Foundation was able to perhaps see some increases in those activities by initiating them and then turning them over to an agency

more appropriately designed to carry them out to applied and development activities.

The Foundation's true mission is one of supporting fundamental research, and we think that is should hew to that line.

Senator SCHMITT. You think as a result of that experience we can better define where the NSF should stop its activities and hand off the mission responsibility to another agency?

Dr. SLAUGHTER. As well as mechanisms to improve the effectiveness of that hand-off which I think has been critical. The technology transfer research——

Senator SCHMITT. If you wish to supply any additional summary testimony in that regard for the record, we would appreciate it.

Dr. SLAUGHTER. We would most happily do so because that is an important matter.

[The information referred to follows:]

Question. What has been the general assessment of the success and limitations of NSF's applied (vs. basic) research programs?

Answer. Up to fiscal year 1981, "applied research" was administered either as a separately identified "applied" program or as a program focussed on a given problem area. Overall, these activities were successful. Research carried out with NSF support in these programs has led to results whose importance and relevance were recognized by mission agencies and the private sector. Some examples include the transfer of solar and geothermal energy research to the Department of Energy, certain earthquake related efforts from NSF to the U.S. Geological Survey, and the current use of integrated pest control management techniques.

The Foundation's experience over the past decade led to the view that characterizing research as either "applied" or "basic" is less relevant than its potential contribution to the development of knowledge—knowledge that strengthens the science and engineering disciplines, or knowledge that contributes to the solution of problems. What is essential is that the research pass the test of rigorous peer review; be of the highest intellectual quality; and be disseminated openly and expeditiously to the scientific, engineering and other potential user communities. This philosophy is reflected in the manner in which the Foundation currently manages its research programs. The majority of NSF research funds will continue to be used for support of high-quality science driven research generated by activities at the frontiers of science and engineering. Care will be taken to insure that when work progresses to the point at which development or later stages of utilization are reached, reduction to practice will be accomplished by either mission agencies or the private sector.

Dr. SLAUGHTER. Continuing on, Mr. Chairman, I would just like to underline the fact that we believe that not only is our mission clearly the one we have just discussed, but that we manifest that through the way in which we provide resources to the communities who do the major amount of research in this country. Eighty-three percent of our funds go to our colleges and universities where the bulk of the fundamental research that we support is accomplished.

Our responsibilities vary from discipline to discipline, of course. In some areas like chemical engineering, mathematics, environmental biology, anthropology, and civil engineering, NSF is almost the single supporter of basic research in the country. Certainly in most cases that I mentioned, at least 90 percent of all the research accomplished at our universities in those areas is provided by the NSF.

In some areas we perhaps provide somewhat lesser levels of support, with very important levels in chemistry, electrical engineering and earth sciences and materials research. Ground-based astronomy is another area that is almost totally dependent upon support from the NSF, not only in terms of support to individual re-

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searchers but in supporting the five national astronomy centers where the primary supports of instrumentation and equipment is available to the astronomical community.

Senator SCHMITT. Has the relationship, if any, between the NSF and NASA been defined relative to the large space telescope?

Dr. SLAUGHTER. We are continuing to further define that, but the answer to that is yes. The National Science Foundation largely will have the responsibility for those things having to do with the ground-based support of the activities. There will be a lot of additional astronomical work that will result from the work of the space telescope that will have an impact upon ground-based astronomy, and we will continue to have that—NASA having the space-based astronomy. The interface between those two is continuing to be developed between interactions between our astronomy persons and theirs.

Senator SCHMITT. Has there been any investigation of the feasibility or desirability of the NSF gradually becoming a managing operator of the science activities related to the large space telescope or potentially to astronomical exploration?

Dr. SLAUGHTER. I think very early on there was some examination of that possibility, and the decision, or at least the thinking at the time was that there should continue to be a strong role in science management of many of the activities by NASA, and that what we needed to do is to develop a better set of guidelines through which we collaborated in seeing to it that the broad spectrum of astronomical support was provided.

Senator SCHMITT. I infer from that, then, that the space-related aspects of an astronomical observatory in space are so unique and pervasive that it does not seem appropriate or desirable for the NSF to have the same type of oversight on a space astronomical facility that they do have over the DLA in New Mexico.

Dr. SLAUGHTER. That is correct, and I think it was also considered in light of the probabilities of the levels of budgetary support that would be needed within the Foundation. It just did not seem to be a realistic direction for us to pursue in light of those kinds of reactions.

Senator SCHMITT. I understand that pragmatism, but if you could summarize for our record the pros and cons of eventual NSF management of a facility such as the large space telescope, the science aspects of such a facility, and incorporation of NASA management of the operational aspects I would appreciate it.

Dr. SLAUGHTER. We will provide that.

[The information referred to follows:]

Question. Summarize the pros's and con's of NSF's assumption of all science responsibilities for space astronomy, many of which are run within NASA.

Answer. The mutual interdependence of ground-based and space-based astronomy is very strong and is growing. NSF is designated the lead agency for the former, while NASA has primary responsibility for the latter. New capabilities in space astronomy open new directions and increase the demand for ground-based activity, both theoretical and observational.

Certainly there is a need for coordinated long-range planning for astronomy from the ground and in space. NSF and NASA jointly supported an analysis of "Astronomy and Astrophysics for the 1980's" carried out by the Astronomy Survey Committee under the auspices of the National Academy of Sciences. This study, to be published in the spring of 1982, recommends a program of ground-based and space-based activities needed for a healthy U.S. program in this decade.

The science responsibilities for space astronomy are not easily separated from other responsibilities within NASA for space astronomy. The scientific, engineering, scheduling, and logistical aspects of space astronomy projects are closely interwoven, probably requiring almost daily coordination at most phases of a project. Thus, we believe the particular logistical requirements of space-borne astronomy are such that NASA should continue to be the agency responsible for managing it.

The Foundation believes the present distribution of responsibilities to be viable and to be working well, generally.

Dr. SLAUGHTER. You mentioned in your comments your concerns about human resource situations in our country. The NSF programs are estimated to support some 15,000 scientists and engineers through our programs, and about 9,000 graduate students are directly involved in the research activities which we support on grants to our colleges and universities.

We think that is a very significant part of the overall program of the Foundation. You are aware also that NSF has some special kinds of responsibilities. We are responsible for budgeting and managing the U.S. effort in the Antarctic. The U.S. national program in Antarctic research is managed fully by the NSF.

We also have a number of international activities for which we are responsible. We manage some 30 bilaterals between the United States and other countries. In some of them we are the lead through agreements with the Department of State. We also have been very active over the past several years in working with a number of industrial organizations. In particular, our small business innovation research program has provided some 300 awards to small businesses throughout the country.

We have a set of activities called university-industry cooperative research centers where we have established six centers in major universities throughout the country. These are centers initiated with Government support with the full intent of becoming at some time supported fully by the private sector.

One at MIT is now fully supported by industries in that area. There is another one on computer-aided design at Renssalaer which I think you may have had an opportunity to see during your visit there last spring, which now has 70 percent of its support coming from industry.

The primary justification, certainly, for NSF support is because we believe that we are in the best position of providing the kind of long-term support necessary for scientific development. Sometimes very large investments, very risky investments are necessary, and these are the kinds of investments that the private sector part of our country is not really in the best position to provide.

Therefore, further developments of fundamental scientific knowledge are going to come from a wise program of investment on the part of the Federal Government, and certainly the NSF has a responsibility in this area.

I will not read, Mr. Chairman, but included in the testimony that I have provided to you are several examples of specific research programs that we have done in conjunction with private industry. I think they are good indications of how successes can be derived from the kinds of investments we have made, and I will just simply bring those to your attention. They will be in the record as part of my testimony.

Our fiscal year 1983 budget request was developed fully within the context of the economic recovery program of the President. We recognize that science as well as all other parts of this country need to examine ways in which it could more effectively utilize the resources available to us. Our program priorities were carefully reviewed to make certain that the largest possible return would be received from our investments.

Recognizing that the Foundation's responsibilities are broad and diverse made it very important, in fact crucial, on our part. We had to weigh a number of different and in some cases conflicting alternatives: the broadness of our programs across all the scientific and engineering disciplines, the need for continuing to support our national research centers and at the same time recognizing the importance of not removing support from needy individual investigators, the fact that there are serious problems requiring increased support for research instrumentation and research facilities while at the same time there are a number of scientists and graduate student research assistants who need support.

We needed to make certain that our core research programs were supported, while at the same time being able to identify wide financial support for new initiatives. Recognizing the importance of science and engineering education in this country and at the same time realizing the need for improving opportunities for women and minorities to participate were considerations that were inherent in our examination in development of our fiscal year 1983 budget.

We believe our budget request does take all of those things into consideration and helps the country in developing an effective federal strategy for not only maintaining the Nation's science and technology base but also provides us with an opportunity to move into some new and strong directions.

The National Science Board certainly plays a strong role in this, and it is unfortunate that Dr. Branscomb cannot be here to explain that role himself, although it is contained very illuminatingly in his testimony.

We receive considerable support from research and academic communities, from the various advisory committees at the Foundation, from our own staff, of course, and from representatives of the Office of Management and Budget and from the Office of Science and Technology policy. Your colleague from the State of New Mexico, Jay Keyworth, played a very strong role in supporting the Foundation's continued efforts in science and technology.

We asked ourselves the question first of all, how do we insure the maximum amount of excellence and promise from those things that we support. That was the number one criterion in our decisions. We also recognize that it is very difficult to anticipate where breakthroughs may occur, and so it is important to provide a base of support across a wide variety of disciplines.

We also recognize that there are certain fields that are ripe for development and it is important to make certain that we provide the kind of support necessary to help those fields develop in such a way that they can bear fruit for problems facing the country today.

And finally, as I indicated earlier, we are concerned about being able to expand and improve the quality of our scientific and engineering personnel base.

Senator SCHMITT. If I could interrupt one more time, do you feel that with this budget and with the trends in this budget relative to science education that we have turned the corner and that science and engineering students are not only going to be more plentiful but better qualified?

Dr. SLAUGHTER. No, I certainly do not feel we have turned the corner, Senator Schmitt. I think our budget focuses on the need for strong support of research in science and engineering, and I think if you examine our budget carefully, as you and your committee will, you will see that that is where our emphasis has been placed. There still is a great deal more that needs to be done at all levels in the science and engineering education—post-graduate, graduate, undergraduate levels and pre-college.

We are quite concerned about the fact that too little emphasis has been given to the needs for pre-college math and science instruction in this country since the period ended that had been initiated with Sputnik, and we are proposing in our 1983 program a new set of directions we believe can represent an initial start for bringing together the kind of national consensus to address that, and I will make some brief comments on that in just a moment if that is okay.

Senator SCHMITT. Please proceed.

Dr. SLAUGHTER. The emphasis that the Board provided and the guidance they provided to us in developing our budget was that we continue to emphasize the physical sciences and engineering and that we also provide emphasis in an area with which you are very familiar, and that is the importance of the earth sciences to better understanding of the nature of our earth, the development of a better understanding of the needs on how we find minerals and chemicals and important resources for continuing the growth and strengthening of the country, as well as recognizing the important activities that are occurring in the field of bioscience and biotechnology. Those are emphasized in our budget.

Where possible and where there are great needs, we also have placed emphasis on research instrumentation. $95 million is contained in our fiscal year 1983 budget request primarily earmarked for addressing some of the most important research instrumentation needs in the discipline that we covered. Dr. Langenberg will say more about those later.

Senator SCHMITT. Dr. Slaughter, do you personally believe that in light of the revelations in bioscience currently under way, literally the unraveling of 4 billion years of evolution, that we can expect within the foreseeable future to see a decline in the need for health care as a result of the prevention of disease or absolute cures for disease or injury if they occur?

Dr. SLAUGHTER. I certainly do not see, in what I would identify as the future as represented by measuring in my lifetime, that we are going to be able to see a decline in that need. I think that we are only beginning to scratch the surface as a result of some of the very fascinating things that are occurring in biosciences and biotechnology.

Certainly we are beginning to unravel some things that will help us a great deal in addressing how to develop cures for major diseases and impairments that affect our health, but I think there is

going to have to be an increased investment. That is not a field I am totally familiar with since major responsibility for health sciences is the National Institutes of Health, but the NSF feels that its activities in improving understanding of biological processes have been and will continue to be important in helping our medical researchers develop further understanding of the principles of improved health care. I just do not see that declining any time soon.

Senator SCHMITT. My problem is if it does not start to decline, and I see no other way for it to decline other than through prevention and absolute cure, we are going to go bankrupt because of medical costs in this country before we go bankrupt because of retirement security costs.

Dr. SLAUGHTER. It does represent a major dilemma for the country.

Senator SCHMITT. I would rather look at it as an opportunity. It would seem to me that there really is only one way in which we are going to change the current trends of health care costs, and that is through basic science and the applications of basic bioscience to begin to significantly prevent disease or, if it occurs, cure it absolutely rather than continuing to have to depend on ever more expensive treatment.

Dr. SLAUGHTER. Yes. From our point of view our response would be in the science area, and as I indicated, we believe that our responsibility is to help support those fundamental studies in basic and biological sciences.

Senator SCHMITT. Do you think we are doing everything that is appropriate in that support in the NSF program?

Dr. SLAUGHTER. I am sure the answer to that is no, Mr. Chairman. I am sure that there are needy areas that we are not being able to support. Our success ratio is measured by the number of quality proposals that we are able to support. It does indicate that some activities, if we had the funds to support, we would, and they are not being supported, so we are not doing all we could.

Senator SCHMITT. Let's put this in number perspectives. What is the budget applied to basic bioscientific research and related fields?

Dr. SLAUGHTER. Well, it is somewhere in the neighborhood of $150 million.

Senator SCHMITT. So it is $150 million of research that could be loosely defined as bearing on problems of prevention and cure of human disease.

Dr. SLAUGHTER. In a quick breakdown, about $85 million is in physiology, cellular, molecular biology; another $34 million on behavioral and neurosciences, and $45 million in environmental biology.

Senator SCHMITT. That certainly is applicable. So $150 million in NSF programs. That would have to be considered somewhat more basic, I would hope, than what NIH is doing, but still there is a lot of overlap; $150 million compared to medicare costs and medicaid costs that have exceeded $30 billion in the budget for fiscal 1983. I believe I am close to the mark. One never knows. You wait until the supplementals to find out just how much they are going to cost.

It seems to me that is a remarkable imbalance when you look at the rate of increase of the Federal burden of health care costs, and

not even considering the burden on individuals and on States and on the total economy through business-supported and other insurance programs.

I just want to make it clear that it certainly is not my feeling that we are making an adequate investment in this revelation which we have started in biosciences and biotechnology. Literally, as I said before, we are looking at how well evolution has engineered the human body to protect itself, to defend itself, and where those protections and defenses prove inadequate, to augment them through techniques that have few, if any, adverse side effects.

So I realize the dilemma you are in and that you would like to do much more. I just hope that others who are aware of this testimony recognize just how small this investment is relative to the total problem that we face in health care costs, literally a problem that will bankrupt the country in the next decade or two unless we come to grips with it.

Dr. SLAUGHTER. Your point is a very strong one, and I would just say the National Science Board, the staff of the Foundation have spent considerable time in examining our program in this area, and the Board has encouraged us to develop an even stronger program in those related to human biology.

We also, I might point out, believe that we have a major contribution to make in plant sciences as a part of our biological program also, so there needs to be some greater focus in some of these directions.

Senator SCHMITT. There is no question about that. There is a very strong overlap in many areas, not the least of which is nutrition, and one of the best ways to prevent disease is to start out right with the preborn and newborn child receiving the nutrition necessary to develop the protective systems that will serve him or her well throughout their life. That is particularly important as we approach that time, when, as Tom O'Toole and his coauthor, whose name escapes me right now, have suggested in a new book to come out, we approach that time when people live as long as trees.

Dr. SLAUGHTER. We have got a lot to learn before we are ready to live that long.

Senator SCHMITT. Yes, but what is going on right now in the understanding of human physiology is aimed very, very specifically in many cases at the aging process, and once you clearly understand the aging process, then the potential is very real for human beings to live far longer than they are living today, by factors of two and three.

Dr. SLAUGHTER. It is fascinating to contemplate.

Senator SCHMITT. It also can be very disturbing because the societal implications of such a revolution are mind boggling, to say the least.

Please go ahead.

Dr. SLAUGHTER. Certainly.

I indicated that in mathematical and physical sciences they have an emphasis there which continues the priority that has been established by the Foundation in the past. We show approximately a 9.5-percent increase over fiscal year 1982, the emphasis being in the computer sciences, particularly experimental computer sciences, trying to improve the quality of the computer networking

that is possible amongst the major universities doing research in computers.

There is a set of activities to improve some of the major facilities in the mathematical and physical sciences, improvements at the Cornell University electron storage ring, as well as improvements at the Indiana University cyclotron. We believe that a better important part of our activities in mathematical and physical sciences needs to be directed toward improving our capacity by doing experimental research, which certainly underlies all the activities in that directorate, with the possible exception of mathematics.

Engineering continues to be a high priority. In fact, it is the highest priority, a 9.8-percent improvement about our fiscal year current plan. The emphasis there is in chemical engineering, robotics, manufacturing processes, communications, and computers.

We believe that the Foundation's new directions in engineering research represent one of the more important areas for continuation, and we believe that needs to be continued and, in fact, expanded in the future. The biological and behavioral social sciences about which we have been talking have shown their major change in the behavioral and social sciences aspect.

Certainly if we follow the example you just mentioned about aging—and I agree wholeheartedly a great deal more needs to be known about the societal effects—behavioral and social sciences would play an equally important role as with the biological sciences in making that a reality.

If you recall, the March request of 1982 for behavioral and social sciences showed a rather significant decrease in support. A correction was made in that in midyear, about a 50 percent correction, so the level was increased from $21.1 million to $32.3 million. In fiscal year 1983 it contains an increase of only $500,000 over the fiscal year 1982 number. We felt it would be better to have the mid-1982 adjustment than to show a bigger increase in fiscal year 1983. The increased support will provide an opportunity for continuing research in the development and maintenance of large economic and social data bases and in improved research methodologies.

In the biological sciences, nitrogen fixation and photosynthesis represent major activities in plant sciences research. Cellular and neurochemical mechanisms of nerve growth and long-term ecosystem response to environmental perturbations are other major areas of activity in the biological sciences. I might add the budget contains an increase of 21 percent for instrumentation in the biological sciences.

I already mentioned Earth sciences research: The need for more understanding of the development of petroleum and minerals, the need for a great deal of basic research. Work in seismic reflection profiling techniques, for example, has helped us to learn a great deal more about geological structures to at least 50 kilometers below the continental surface.

You know the importance of this research, the importance of continuing to learn more about the development and the origins of the Earth. Because it is so important, the National Science Foundation has requested an increase of almost 18 percent for Earth sciences research in fiscal year 1983.

Senator SCHMITT. Dr. Slaughter, I cannot let that go by without some comment. I particularly hope that you will provide the committee with some information for our record on how you see your Earth sciences program relating at least in part to the need to find nondestructive means of assessing the mineral resources of public lands, and particularly wilderness areas.

I have a very strong feeling for those who wish to protect these wilderness areas and other lands. I agree with them completely.

At the same time, it would be foolish for a nation to be sitting on resources at a time of national emergency and not know where those resources were located. So while I would not expect the NSF to be involved in this type of activity, nevertheless the NSF basic research almost certainly has some applicability and should have as much as is reasonable to the mission agency responsibilities, primarily those of the U.S. Geological Survey.

I should add here that I compliment the Secretary of the Interior for following through on my suggestion, and I am sure that of others, that the USGS be moved back into a scientific and applied scientific agency rather than one that is primarily concerned with regulatory oversight of the mineral industry.

I think your cooperative programs with them now will be far stronger than they were in the past when their regulatory activities obviously overwhelmed management.

[The information referred to follows:]

Question. How is the earth sciences program of the NSF coordinated with that of the U.S. Geologic Survey?

Answer. Coordination is broad-based, and helpful. NSF staff are in frequent contact with one or more USGS personnel at levels ranging from the Director of the USGS to individual scientists. Attendance of each agency at the other's panel review of proposals serves to avoid duplication. Coordination has greatly increased in recent years to ensure maximum sharing of information at the working level. Two senior Survey employees serve on the Division of Earth Sciences' Advisory Committee.

Question. Has there been any discussion between NSF and the Department of Interior regarding the assumption of part or all of USGS's earth science research program?

Answer. NSF has discussed the effect of reduction of the USGS's extramural funding (especially in the Earthquake Hazard Reduction Program) on proposal pressure in the Earth Sciences Division at NSF. Such reduction will certainly increase the number of proposals. NSF cannot fill the USGS role in the earthquake prediction area that has been assigned to the USGS by Congress. Other extramural funding by the USGS is small and also is entirely related to the Survey's mission. It would therefore be inappropriate for the NSF to assume the Survey's program.

Question. What are the prospects for finding some non-destructive means of identifying earth resources, e.g. minerals, in remote or wilderness areas?

Answer. A number of methods are available for non-destructive exploration for earth resources. These include the classic geophysical methods (electromagnetic, magnetic, electrical resistivity, and seismic to name the major ones) to geochemical surveys analyzing trace elements in small soil or rock samples to the recently developing satellite remote sensing methods such as infra-red spectrometry. New methods are being developed by industry, the academic community, and the USGS; NSF has also funded proposals in this area. None of these methods define the content and extent of an ore body, however. Ultimately the potential mineral deposit established through non-destructive methods must be tested by drilling, trenching, or excavation.

Dr. SLAUGHTER. We also are encouraged, Senator. There are several cooperative activities between the Foundation and USGS; we will be pleased to provide information on non-destructive means of

assessment such as seismic profiling. It is producing some fantastic evidence that we have not explored on the continents until now.

Senator SCHMITT. Of course, I have felt for a long time that the bridge that we must build between those competing social interests, interests of environmental protection versus those that believe we must assess our natural resource base, is going to come through modern science and technology which allows us to do things we just could not do 30 or 40 years ago. Let us take advantage of that and build that bridge so we all start working on the same problems instead of fighting each other.

Dr. SLAUGHTER. Yes, thank you, Senator. Let me turn now to the National Astronomy Centers, an important part of the Foundation's program. We need to maintain and continue the operation of the major instruments and facilities. During fiscal year 1983, we will close some smaller instruments, as two 16-inch telescopes. We have been able however, to keep the major instruments in operation in spite of budgetary restrictions.

In one major step, NSF transfered the scientific balloon responsibility to NASA where most of the support was being provided. We also decided to begin to upgrade some of the ships and the on-board equipment needed by oceanographic researchers.

Through these efforts, we hope to maintain the equipment and facilities required to continue high quality, research in oceanography.

The ocean drilling program is undergoing change as reflected in the fiscal year 1983 budget. As you will recall, the ocean margin drilling program planned by NSF depended upon strong support from the U.S. oil industry. However, the oil companies decided they would not wish to continue that program past fiscal year 1982. Consequently, we have terminated the ocean margin drilling program.

We believe, however, that important scientific benefits can be obtained by continuing a program of ocean drilling. The research effort for fiscal year 1983 and beyond is designed to address some questions about subduction zones—where new crustal material is formed along ocean ridges—the age of the oceans, and the formation of continents.

To do so, it makes sense to examine what sort of facilities will be required. We have been using the *Glomar Challenger.* As you know, it has been a successful vessel, providing the tools for the preliminary studies that led to confirmation of the plate tectonics theory. However, the *Challenger* is reaching the end of its useful life and the time when it can provide no longer the necessary equipment to make further scientific investigations.

We are continuing to examine the possibility of using the *Glomar Explorer.* We believe now it would be possible not only to increase the scientific potential by moving from the *Challenger* to the *Explorer,* but it could be done without a significant increase in operating cost. The *Explorer* is larger and requires more fuel, but it can carry more scientists, stay out longer, and operate in areas where the *Challenger* cannot.

We also are examining what would be required to convert the *Explorer* to a drill ship. The National Science Board last week strongly endorsed this effort. We will proceed and provide the Con-

gress and your committee the information necessary to support a recommendation.

I already mentioned the Antarctic program. Let me emphasize that the President recently reaffirmed the administration policy: the U.S. Antarctic program is to be maintained at a level providing an active and influential presence in Antarctica, and NSF is to continue as the agency responsible for managing and budgeting the program. The President added that the Foundation's budget in the future should recognize the Antarctic program as important in its own right. The program should not be affected by increases or deletions in other NSF programs. The Antarctic program should be supported at a level necessary to carry on high-quality research and the important presence there; it should not be affected by decisions in other scientific areas. We think it is an important statement.

Senator SCHMITT. Is your relationship with the Navy changing with respect to Antarctica?

Dr. SLAUGHTER. NSF's relationship with the Navy continues to work well. The Navy provides support to us in the Antarctic; we continue to be the managers, receiving necessary aircraft and ship support from the Navy.

Senator SCHMITT. You will continue to budget for Navy support?

Dr. SLAUGHTER. That is correct. A major change this year is that the money for Coast Guard icebreakers is added to the NSF budget.

Senator SCHMITT. I understand.

Dr. SLAUGHTER. I want to discuss briefly the work of the scientific, technological, and international affairs directorate which covers a wide range of activities. In the international arena, NSF funds 30 bilateral agreements with technologically advanced Western European countries and with Latin America. Funding for these agreements is strengthened in fiscal year 1983, and we are examining new opportunities in some of the lesser-developed countries. These cooperative research agreements provide access to important research facilities, research sites and first-rate minds in foreign countries. We think the program is important, and we want to continue it.

I mentioned NSF-supported activities involving industry and universities, the cooperative research programs, and the cooperative research centers. We believe NSF's initiatives have helped to bring universities and industry together and to identify possibilities for collaborative projects.

The fiscal year 1983 budget request also includes an expansion of programs to broaden the participation of women and minorities in research careers in science and engineering. Their relatively low level of participation represents a national dilemma, and we need to do something about it. Consequently, NSF is asking increased funding for visiting professorships for women, for the minority research initiation program, and for research improvement of minority institutions.

Minorities constitute about 22 percent of the population of the United States, and yet less than 4 percent of the science and technology work force. We believe the country shortchanges itself if it does not move to correct this imbalance, and NSF is attempting to help make the correction.

Senator SCHMITT. Science and engineering today, in view of the shortages of manpower that exist, offers a tremendous opportunity for young men and women in the minority groups of this country. They are, as you have said, greatly underrepresented.

Counselors, as I see it, have tended not to advise careers in science and technology. And so they are not participating and broadening the base of minority activity throughout the economy.

I would say, however, it appears that the Southwest Resource Center in New Mexico is functioning quite well. They are participating now directly and actively in the state science fair, which I think also, had over 30 percent growth in student participation in 1 year in New Mexico.

It is really fascinating how rapidly the science fair activities are growing. Having toured the Albuquerque area exhibits the other day, I was amazed at the quality of work and the imagination that is being shown by these young people in their science fair exhibits.

If you have an opportunity to visit Socorro, the site of the State science fair, I am sure they would love to show off their wares to you.

Dr. SLAUGHTER. It is exciting. The State of New Mexico should be commended because the University of New Mexico, I believe, has the highest percentage of Mexican Americans and Native Americans involved in science and technology of any university in the country. I talked with President Davis of the university; he has a high personal commitment to increase participation by minorities.

Senator SCHMITT. It is important, but still far too low in a State with about 35 percent of the population identified as Hispanic. It comes to mind, I believe, that next year New Mexico will host the International Science Fair, if I am not mistaken. Maybe we will see you out there then.

Dr. SLAUGHTER. Your comment leads into my concluding remarks which are concerned our science and engineering education. You have already pointed out the sad state of much science and mathematics instruction in the primary and secondary schools.

Requirements of achievement for graduation are declining. Correspondingly, requirements for admission to some of the better institutions, colleges and universities, are declining. Incentives and rewards for teachers are lacking, and the quality of teachers' preparation is declining, too.

NSF is concerned about severe shortages of mathematics, physics, and chemistry teachers in the secondary schools and about many teachers in those schools who are poorly prepared or who lack credentials for teaching.

Many courses offered in many public schools lack the content to excite and encourage a student for the pursuit of science and mathematics. It is a grave matter requiring national concern.

The fiscal year 1983 budget request for science and engineering education shows the foundation's continuing emphasis on graduate fellowships; It contains $15 million to continue those fellowships.

And to make a new start on the issues I just mentioned, we are establishing the National Science Board Commission on Pre-college Education in Mathematics, Science, and Technology. It will do three things:

First, it will focus national attention on the problems and opportunities in pre-college education in science and mathematics;

Second, it will develop mechanisms—by working with State and local school districts, with scientific and professional societies, with representatives from industry, business, academic and educational institutions—to not only examine the dimensions of the problems but also to identify ways in which the country can address them.

Finally, the commission will help develop a new consensus—we believe it is badly needed—for what the Federal Government can do, what the NSF must do to address these problems.

We are excited about the responses we are receiving from people who have agreed to serve on the Commission. It will have 15 to 18 members, all of whom, either by their past experience or their personal interest, are particularly concerned about the development of young people and the need for improved capabilities in science and mathematics.

I am pleased with the response of the Board, I am pleased with the response of the Foundation, and I am pleased with the response we have received from Congress to the proposed commission.

I have talked longer than I anticipated, but I appreciate the opportunity to explore these avenues with you. I would like to turn the microphone over to Dr. Langenberg, who will talk specifically about the issue of instrumentation for the science and technology base.

Senator SCHMITT. We appreciate the interchange here. Let me ask you one final question in the context of your testimony. And that is, why should we not assume that the National Science Board commission on precollege education is not typical of other commissions that are created to avoid addressing the problem?

Dr. SLAUGHTER. Because this commission will address the problems. Many commissions are established to study an issue; this commission will not do so. The problems are already identified. The question is: How do we put together the national framework to solve them?

Anyone can come up with the problems, but very few can propose the solutions and make them happen. The commission will produce an action plan rather than a study. Some 30 studies have been completed, all of them condensed to a few major essentials. You identified them in your opening comments, and I have referred to them.

The commission will work for 18 months. It will produce a report at the end of each 6 months and a final report at the end of 18 months. The final report should present the action plan involving all of the entities I have described. And the commitment the Board and the NSF staff will apply to it will make the difference. I believe it is absolutely imperative that this effort be initiated soon.

Senator SCHMITT. What if that report says we ought to increase the National Science Foundation's budget by 25 percent per year indefinitely in science education? Do you think that anybody is going to listen?

Dr. SLAUGHTER. I think somebody will listen. I believe it will be incumbent upon me to stand before you and argue for that. And it will be incumbent upon the committees of the Congress to listen

and to join in moving that way if a consensus says that is the right answer.

Senator SCHMITT. Well, depending upon whose numbers you believe, we have an investment shortfall in graduate education alone in this country of at least $1 billion a year—I am not talking about government investment, I am talking about national investment—and it as high as $4 to $5 billion a year.

The NSF and the Labor Department have estimated a 10,000 to 15,000 shortfall per year in graduate degree holders. The Department of Defense estimates that may be as high as 50,000. Whichever numbers you believe, it is a very, very serious situation, that a nation that thinks it is the principal industrialized nation of the world, principal technological nation of the world, principal innovative nation of the world would sit here with that kind of a situation having resulted from misguided policies—not just Federal policies, but policies of industry and other groups within our society.

I do not know what it is going to mean if we wait 18 months for a report of another commission.

Dr. SLAUGHTER. We won't have to wait, Senator. As I said, the first report will come out at the end of 6 months. The problem is that the longer we wait to go into action, the more severe the problem becomes. And it seems to me we must get some of the best minds in the country working together, pulling in and developing a framework of persons willing to commit themselves to solving a problem. We cannot continue another year or two without acting.

Senator SCHMITT. But in the meantime, what is going to convince industrial America that they must invest in the creation of their people resources at rates of investment comparable to what they would put into assuring a continuous supply of raw or other kinds of material on which their industry depends? At the same time they will come back and say, well, we can do more, but we cannot do everything that's required. The Federal Government must itself invest in the redevelopment of the people resource it needs, in defense and nondefense areas.

How do we insure that we don't just sit around for another 18 months? Frankly, I think there is a strong tendency right now to sit around for another year or so while we digest the activities of the new Commission on Social Security, while that time bomb keeps ticking away.

Everybody who has spent any time at all looking at that problem knows that with the retirement of the baby boom, you will begin to require that individuals invest 25 to 40 percent of their personal income in paying for the retirement of their elders. And I think anybody who thinks about behavioral science at all knows that is going to be a tremendously divisive situation within our society, in addition to the fact that we will not be able to afford it.

But we still let that fuse burn, without taking what are clearly rational, commonsense steps to repair the situation. Why can I expect, and this committee expect, and the American people expect that we will not let the educational time bomb tick away for another 18 months, while we wait for the final report of this commission?

Dr. SLAUGHTER. Because things are happening for several reasons. Your statement last year to us—I recall it vividly, that not

only are we eating our seed corn, but we are shooting the farmer—has had significant impact. I apologize to you, but I have used your comment a number of times, always giving reference to you, because I think it is important.

A major meeting will take place in April in New York, chaired by Ed David of Exxon to address the engineering problems. The Congress will be involved in the meeting, and I hope it will be one of the efforts that prompts industry to move ahead.

Several other parallel efforts are underway. The problem, Senator, is that they are all unconnected. I am concerned that we are not being as effective as we might be, because the efforts are not being tied together.

So we will not sit for 18 months; we will be bringing together the science and engineering communities. Chief executive officers of major industrial firms will be members of the commission. Each will have an opportunity to influence his particular community. There also will be university presidents and superintendents of school districts on the commission. I will be providing the names to you shortly. I think they are going to make the difference.

Senator SCHMITT. Well, thank you. I hope you are right. And I wish the commission well.

[The statement follows:]

STATEMENT OF DR. JOHN B. SLAUGHER, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and Members of the Committee, I am pleased to be here this morning to discuss the Administration's proposed fiscal year 1983 budget for the National Science Foundation. With me are Dr. Lewis M. Branscomb, Chairman of the National Science Board, and Dr. Donald N. Langenberg, Deputy Director of the Foundation.

I will begin our presentation with a brief overview of the Foundation's budget request. The proposed budget for fiscal year 1983 totals $1,072.8 million, an increase of $76.6 million or 7.7 percent over the fiscal year 1982 current plan. The increase for research and related activities, exclusive of a transfer of budgetary responsibility from the Coast Guard to the Antarctic Program for icebreaker support, is a little over $71 million or 7.3 percent above fiscal year 1982. This increase, during a period of budgetary reductions in many Federal programs and activities, reflects the importance which the Administration attaches to the support of fundamental research and to maintaining the vitality and health of the Nation's research enterprise

When I have completed my overview of the Foundation's budgetary priorities for fiscal year 1983, Dr. Branscomb will comment on the role of the Board in formulating these priorities and provide you with an update on the status of the National Science Board's Commission on Pre-College Education in Mathematics, Science and Technology, one of the most important initiatives in our plans for fiscal year 1983. In addition, he will comment on opportunities for encouraging the private sector to participate more effectively in upgrading scientific equipment in the universities, a subject which is of particular interest to this Committee.

Because of the centrality of instrumentation to cutting-edge research in virtually every field of science and engineering which the Foundation supports, and because of the growing concern which we have regarding the continuing adequacy of the research instrumentation base in the Nation's universities and colleges, I have asked Dr. Langenberg to follow Dr. Branscomb with a brief discussion of recent Foundation steps, taken and proposed, to upgrade such equipment. The need to improve the quality of university research instrumentation in the Nation was one of the concerns in the forefront of our thinking as we established our priorities and shaped our budget request for fiscal year 1983.

INVESTMENT IN RESEARCH: IMPACTS AND BENEFITS

In fiscal year 1983, the Federal government will invest almost $5.8 billion in the support of basic research. Most of those funds will be used to support mission-oriented programs in areas of major Federal responsibility—defense, space, energy,

health. The role of the National Science Foundation is unique in that it alone was established to "promote the progress of science" through the initiation and support of basic research in all fields of science and engineering. In fiscal year 1983, it is estimated that the Foundation will account for 17 percent of the total Federal obligations for basic research.

What is the general impact of the Foundation's program? There are several ways to answer this question. First, the Foundation supports research in a very wide range of the physical, engineering, geophysical, social, biological and behavioral sciences. This support complements the research programs of other Federal mission agencies and helps to insure a proper balance across fields and areas to maintain the overall strength and vitality of the scientific and engineering knowledge base of the Nation.

In fiscal year 1983, nearly 83 percent of the funds obligated by the NSF will go to support work in universities and colleges. The Foundation's overall position as one of the top two or three Federal funders of research at our leading research universities means that it is of major importance to the work which they conduct.

In certain fields like chemical engineering, core mathematics, environmental biology, anthropology, and civil engineering, NSF supports approximately 90 percent or more of the university-based, fundamental research. In other areas such as chemistry, electrical engineering, earth sciences and materials research, the Foundation provides at least 50 percent or more of the Federal funds for basic research in universities. Similarly, its five National Astronomy Centers make advanced, unique instrumentation available to over 1,300 astronomers every year, a large portion of the Nation's astronomers. As the major supporter of ground-based astronomical research, NSF is the primary source of new instrumentation in this field of science.

The impact of the Foundation's programs may be conveyed in still another way. In fiscal year 1983, it is estimated that about 14,600 scientists and engineers will be supported under awards from NSF's major research programs. Most are located in nearly 400 colleges and universities in all 50 states. These research grants will also provide support for some 9,000 graduate students.

In addition to the significance of our research programs and support of national centers and instrumentation for university-based investigators, the Foundation is responsible for budgeting and managing the entire United States national program in the Antarctic. NSF programs also strengthen U.S. science by broadening its base. For example, through our international programs we support and manage bilateral agreements with some 30 countries, executing lead agency responsibility in a number of them at the request of the Department of State.

NSF's Small Business Innovation Research Program, initiated in fiscal year 1977, has made over 300 awards to small businesses in 36 states. This activity has been widely recognized as a model for similar programs elsewhere in the Federal Government. Finally, under our University/Industry Cooperative Research Centers program we have, since 1973, provided the 'seed money' for the establishment of six centers. One, at MIT, has subsequently become self-supporting with industry financing while another in Computer-Aided Design at RPI now receives over 70 percent of its support from industry.

As you and the other Committee Members are aware, Mr. Chairman, the primary justification for Federal support of basic research is its long-term contribution to the Nation's science and technology base. Because such investments are often large or very risky and because their benefits are not easily capturable in the market, the private sector will tend to under-invest in such work. While no one can foresee the exact nature of the problems and needs which this country will face tomorrow, we can be certain that basic scientific and engineering knowledge will lay the groundwork for addressing them. The Foundation has played a key role in this process since 1950.

With this broader perspective in mind, it is often useful, and interesting, to point to some of the practical benefits which might flow from recent work funded by NSF. These examples highlight the potential impact of the Foundation's programs on our daily lives and the continuing importance of the national investment in fundamental research.

While carrying out a basic research project to learn more about soluble catalysts, substances which speed up or slow down the rate of chemical reaction, Professor George R. Newkome and his research group at Louisiana State University in Baton Rouge discovered a class of potential anti-tumor agents that are more active and may prove less toxic than the heavy metal drugs now used in cancer chemotherapy. More testing must be done to identify the most effective and safest anti-cancer agent. These new compounds are about 10,000 times more active than drugs in cur-

rent use for cancer chemotherapy. Since much smaller dosages may be used, unacceptable side effects such as irreversible kidney damage will be avoided.

In a very different scientific area, Dr. E. Philip Krider, Professor of Atmospheric Physics at the University of Arizona and Dr. Martin A. Ulman, Professor of Electrical Engineering at the University of Florida, have collaborated on a successful project which measured radio waves emitted by lightning to a frequency a hundred times higher than ever before, an accomplishment that will help those seeking to diminish the danger of lightning to aircraft.

Their measurements, taken for the first time over water with newly developed instruments, are the first to cover all frequencies between 1,000 cycles and 10 million cycles per second. The vulnerability of aircraft to lightning has increased in recent years. Both because composite materials have replaced metals in their outer construction and because new sophisticated solid state electronic equipment in aircraft is especially susceptible to lightning. Manufacturers who test airplanes and their electronic equipment in order to determine how to protect them must be aware of the different frequencies of lightning so that they can be tested for vulnerability at all those frequencies.

The Robot Research Group of the University of Rhode Island, headed by Professors John R. Birk and Robert B. Kelly, has developed an experimental robot which has "vision." Two television cameras with a computer "brain" enable the robot to select workpieces from a bin of randomly placed similar objects, pick them up, orient them, and carry them to a machine. This robot was developed from six years of research and is the first that can effectively use "vision" to select work pieces from a bin. Not only does it have considerable promise for increased productivity in manufacturing, but it has potential applications in environments hazardous to human beings.

A final, and very recent, example of the kinds of practical benefits which may result from the Foundation's wide variety of programs is contained in a press release issued by the Martin Marietta Company on January 28, 1982.

Dr. Lewis Erwin, du Pont Associate Professor of Mechanical Engineering at MIT, and John O. McCree, a graduate student, worked with officials from Martin Marietta under the auspices of the MIT-Industry Polymer Processing Center, mentioned earlier, to develop an efficient vented compression molding technique for applying insulation to fuel tank parts on the space shuttle. These new techniques could save about $100,000 for each external tank of the shuttle. Since the external tank is the only major non-reusable element of the Shuttle, the total cost savings from the more than 400 planned Shuttle flights could exceed $40 million.

Mr. Chairman, I have a complimentary letter from Mr. Richard M. Davis, Vice President of the External Tank Project for Martin Marietta Aerospace, which I would like to introduce into the record. You may be interested in knowing that the NSF 'seed money' for this Center totalled $500,000. This was certainly a high-leverage investment for the American taxpayer!

DEVELOPING THE BUDGET REQUEST

Mr. Chairman, the Administration's proposed fiscal year 1983 budget for the Foundation was developed within the context of the President's economic recovery program. Every group in the Nation, including the scientific and engineering research communities, will benefit if these critical economic objectives are realized.

As part of the Foundation's contribution to the achievement of these objectives, all program activities and priorities were carefully reviewed to insure that those included in the Administration's request would provide the largest possible return on the dollars invested in terms of the Nation's future scientific and engineering knowledge base. As I have already pointed out, the Foundation's responsibilities are broad and diverse and its role within the academic sector, in particular, is critical.

As in the past, the development of this year's budget request required careful weighing and balancing of many alternatives: among research opportunities in diverse scientific and engineering disciplines; among continuing support of national research centers and user facilities and support of individual investigators; between increased support of much needed research instrumentation and the refurbishment of major research facilities and the support of scientists and graduate student research assistants; between the Foundation's core research programs and its important responsibilities in science and engineering education, international cooperation in science and technology, and the expansion of opportunities for women and minorities to participate in research careers in science and engineering.

As you know, Mr. Chairman, the Foundation's budget request was also developed in the context of the Administration's broader policies and plans for Federal sup-

port of research and development in accordance with the President's priorities and decisions. Since NSF is, among other things, a kind of "balance wheel" to help insure that there is an effective Federal strategy for maintaining the strength of the Nation's science and technology base, its FY 1983 budget request and priorities are also reflective of the broader policies and judgments of the Administration.

As these comments suggest, then, numerous groups and individuals have been involved in these assessments during the past year including: the National Science Board; representatives from the academic and industrial research communities who serve on various NSF advisory committees; the Foundation's management and professional staff; and represenatatives of the Office of Science and Technology Policy (OSTP) and the Office of Management and Budget (OMB).

Several criteria were used in making these assessments. First, and foremost, emphasis was placed on excellence and promise. We asked ourselves: "Which areas of research, which NSF projects and programs, are of the highest quality and offer the most scientific promise?"

The second criterion reflects the fact that key science and engineering breakthroughs often come from unexpected quarters and lead to advances on broad fronts. Thus attention was given to the need to maintain a broad base of support across a wide variety of scientific and engineering disciplines.

Third, certain fields of science and engineering have clear, more immediate potential for contributing to important national economic, productivity or defense goals. These fields were singled out for special emphasis.

Finally, an effort was made to identify a few, potentially significant opportunities for expanding the Nation's scientific and engineering personnel base.

HIGHLIGHTS

The results of this extensive process of assessment are reflected in the Administration's request. As I have already said, the requested increase for research and related activities is a little over 7 percent. The request for science and engineering education this year is down from FY 1982 and will focus on graduate fellowships. Within this overall proposal: Emphasis has been given to the physical sciences and to engineering, with particular attention to computer science, earth science, and electrical and computer engineering; increases are provided in most areas, and support for the social and behavioral sciences has been substantially increased over the reduction proposed in the Administration's revised budget request of last March for FY 1982; an important initiative in science and engineering education is proposed in the establishment of the NSB Commission on Pre-College Education in Mathematics, Science and Technology; programs to support the participation of minorities and women in science and engineering research careers are significantly expanded; and support of major equipment and other research instrumentation will equal an estimated $95.3 million in FY 1983, an 11.5 percent increase over the FY 1982 Current Plan.

Let me now review some of our FY 1983 proposals in a bit more detail.

PROGRAMMATIC OBJECTIVES OF THE FY 1983 REQUEST

Mathematical and Physical Sciences (MPS)

With the development of powerful new theoretical concepts, incisive experimental approaches, and sophisticated modern instruments of unprecedented power, resolution, and sensitivity, the Mathematical and Physical Sciences continue to be in a period of unusual activity and opportunity. Although theoretical understanding is central to progress in science, all of the mathematical and physical science disciplines except mathematics are based primarily on experimental research.

It is therefore essential to maintain an adequate, modern experimental research capability throughout each of the MPS disciplines. This is accomplished with a wide range of research support modes, including individual or group research projects, special instrumentation grants, university research laboratories, and national user facilities.

The overall increase for these disciplines in FY 1982 is 9.5 percent above the FY 1982 Current Plan. The previous emphasis on experimental computer science is carried forward, including planned support for approximately 12 computer research facilities at academic institutions. Support for individual project research is maintained at approximately a constant level of effort. Support is provided for detector and storage ring improvements at the Cornell University Electron Storage Ring and for installing a "cooler" storage ring to improve the energy resolution of the ion beams at the Indiana University Cyclotron.

Responsibility for construction of the Phase II Michigan State University heavy ion accelerator will be transferred form the Department of Energy to NSF. While responsibility for funding the Standford Synchronton Radiation Laboratory is transferred from the NSF to the DOE. These two actions will give responsibility for these facilities to the most appropriate agencies.

Engineering (ENG)

The Foundation has placed a high priority on support of fundamental work in engineering. This emphasis is continued this year. Not only are there many exciting research opportunities in engineering, but much of this fundamental work underpins significant portions of our Nation's industrial base in Chemical processing, robotics, manufacturing, communications and computers. The overall increase for engineering in FY 1983 is $8.9 million or 9.8 percent above FY 1982 Current Plan.

Emphasis this year will be placed on Research in micro-electronics and on basic work related to robotics, manufacturing, and novel chemical and separation processes.

The Foundation's responsibilities in the area of earthquake research are met primarily in the engineering activity. In FY 1983, Budgetary responsibility for the strong ground motion array is transferred to the U.S. Geological Survey where it will be closely tied to their work in earthquate prediction. The Foundation's strong research programs, however, will be retained.

Biological, Behavioral and Social Sciences (BBS)

As you know, there has been an intensive review of NSF's social science and behavioral science research during the past year. Social and behavioral scientists have clarified and conveyed the importance of their research and its long-term significance in meeting national goals. For their part, the National Science Board and the Foundation have carefuly reexamined and reaffirmed the role that research in the behavioral and social sciences plays in improving fundamental understanding of how individuals, groups, large organizations and complex societies function.

A National Science Board statement in June summarized its findings: As with othe sciences, NSF has an integral and distinctive role in enhanceing the scientific capabilities and developing the intellectual tools and resources of the behavioral and social sciences. To implement these conclusions, the Foundation set the FY 1982 level of support at $32.3 million, or 53 percent higher than the Amended March Request of $21.1 million. Our combined request for these sciences for FY 1983, which increases by another $800,000 over FY 1982, will provide $15.3 million for the behavioral sciences, and $17.8 million for the social and economic sciences. These programs will provide improved balance in the support for the maintenance of large economic and social data bases, the strengthening of research methodologies, and the conduct of investigator-initiated studies of social and behavioral phenomena.

In the biological sciences, special attention in FY 1983 is given to research on nitrogen fixation and photosynthesis; cellular and neurochemical mechanisms of nerve growth; and long-term ecosystem response to environmental perturbations. Biological research is becoming increasingly dependent on sophisticated and expensive instrumentation and modern laboratories. The Foundation is responding to these needs by increasing funding in the Biological Instrumentation program by about 21 percent over FY 1982 and continuing a modest program to upgrade marine biological research stations.

ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES (AAEO)

Mr. Chairman, if we look 10 to 20 years into the future, it is clear that the needs for petroleum and minerals will be even greater than they are today. This is the time frame within which we must look for major benefits from the basic research in earth sciences which receives continuing emphasis in FY 1983.

The readiness of the earth sciences for making significant scientific advances has been enhanced by the use of deep seismic profiling techniques which have revealed previously unknown geologic structures up to 50 kilometers beneath the surface of our continent. Major advances in instrumentation also allow geochemical studies to proceed more rapidly than before other pressing societal issues such as land use and waste disposal are additional reasons for augmenting resources for research on the North American continental crust.

In astronomy, atmospheric, and ocean sciences, we hve faced some difficult choices in preparing our FY 1983 budget request. As you know, Mr. Chairman, much of this research requires large facilities. At the national astronomy centers, we have been able to continue operation of all of our major instruments and facilities in FY 1983, though we have been forced to close some smaller ones such as two

16-inch telescopes at Kitt Peak. The national scientific balloon facility is being transferred to NASA. In the ocean sciences, we have decided to undertake essential upgrading of ships and ship equipment at the expense of sea time for ocean scientists over the next year. Though such decisions have been difficult, they must be made in order to maintain the longer term vitality of these important sciences.

OCEAN DRILLING PROGRAMS ODP

In the past year, we have carefully examined our alternatives in the Ocean Drilling Program (ODP). Last summer, the Foundation proposed a stretch-out of the then-planned Ocean Margin Drilling Program to keep the activity within budget targets. The proposed stretch-out would have deferred drilling in the margins with marine risers and well control. When, in October 1981, our petroleum company partners decided that this stretched-out program would not meet their needs, they ended their financial support, as provided in our agreement with them. At that point, we terminated the Ocean Margin Drilling Progam.

However, there is a widespread consensus that very important scientific benefits can be gained only through continuation of drilling in the ocean's floors. Of particular importance is examination of plate boundaries, both at the mid-ocean ridges, where new crustal material is formed, and at the subduction zones on the landward edges of the plates. Better understanding of the activity at these plate edges can contribute to our knowledge of the formation and location of ore deposits as well as to a better understanding of earthquakes. While acoustic survey techniques are of great value when used in conjunction with drilling, they are not a substitute for it.

Comparative studies of the extension of *Challenger* drilling compared to modifications of *Explorer* have produced somewhat unexpected results. Though *Explorer* is larger in size, it can drill more deeply in presently inaccessible areas at roughly the same operating cost as the smaller *Challenger*. Thus, the Foundation has recommended, and the Board approved a go-ahead with the *Explorer* program which would involve detailed design work in FY 1983 and modification of the ship in 1984-85.

This recommendation and its execution will depend, ultimately, on detailed study of the projected costs of conversion and on firming up foreign participation in the operating costs of the program. This will provide the basis for Foundation's recommendation to the Administration on this program later this spring.

U.S. ANTARCTIC PROGRAM (USAP)

The Antarctic program continues to produce unique scientific results with respect to improved understanding of: climatic changes as reflected in the behavior of Antarctic glaciers; the nature of the continent and the surrounding oceans; and the nature of the solar system.

This latter research is pursued through long-period solar observations and the accumulation and study of meteorities from the Antarctic continent.

Recently, the President reaffirmed the policy that the U.S. Antarctic program is to be ". . . maintained at a level providing an active and influential presence . . ." in Antarctica and that NSF is to continue to be the focal point for managing and budgeting this presence. This responsibility is not to be at the expense of other Foundation programs. In keeping with his decision, the Foundation's FY 1983 request has been augmented by an additional $13.4 million to cover the cost of U.S. Coast Guard icebreakers used in the program. Previously these funds were included in the Coast Guard's budget.

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS (STIA)

Unde the Directorate for Scientific, Technological and International Affairs, the Foundation supports a number of critically important programs which contribute to the development of the Nation's scienic and engineering capabilities. These programs enhance national and international sceintific exchange and cooperation. The United States benefits from healthy competition, as well as cooperation, among scientists of many nations. We in turn are better prepared to meet the challenge of making good use of resources abroad, while ensuring continued progress in science and technology in our own country.

In keeping with this philosophy, cooperative research programs with technologically advanced Western European countries and with Latin America will be strengthened by increased funding in FY 1983. In addition to facilitating planning for mutually advantageous, cooperative research projects, these programs provide

U.S. scientists with access to unique research sites, research facilities and first-rate foreign scientists.

As in the past, the Foundation will continue to explore means for stimulating research interactions between universities and industry, with the complementary objectives of accelerating scientific knowledge production and contributing to long-term technological innovation. The Cooperative Research Projects program, which will be expanded in FY 1983, supports individual research projects involving working cooperation between university and industry scientists and engineers. The Industry/University Cooperative Research Centers Program, mentioned earlier in my remarks, will also receive increased support. In addition to the other benefits which we believe these two programs provide, they also provide graduate students with exposure to the styles, demands, and opportunities of industrial research. One of those cited in the press release from Martin Marietta that I mentioned earlier was a graduate student in mechanical engineering at MIT.

Finally, Mr. Chairman, the Foundation's budget request for STIA for FY 1983 includes expansion of our programs to broaden participation of women and minorities in research careers in science and engineering. Their relatively low level of participation in such careers can weaken national capabilities in science and technology and its uses. Funding for the Visiting Professorships for Women program, for the Minority Research Initiation program, and for the Research Improvement in Minority Institutions program is enhanced significantly in FY 1983.

SCIENCE AND ENGINEERING EDUCATION (SEE)

Let me turn, finally, to the Foundation's request for FY 1983 for its activities in science and engineering education.

There are numerous problems facing this country in the level and quality of education available today in science and mathemetics education in the Nation's primary and secondary schools. These problems include the declining level of requirements for achievement in science and mathematics in order to graduate from high school coupled with reduced college admissions requirements. They include lack of incentives and rewards for teachers of mathematics and science and a corresponding decline in the quality of these teachers' preparation for their responsibilities. They include severe shortages of mathematics, physics, and chemistry teachers in our secondary schools with the consequence that many who teach in these areas are poorly prepared and even uncredentialed for such work. They include courses based on rote learning and memorization, rather than experimentation, and curricula which fail to take into account current developments and needs in science and technology. They include classrooms with archaic equipment, much in states of disrepair.

The foundation is not unmindful of these serious problems even though our request for FY 1983 in science and engineering education is limited to a total of $15 million for NSF graduate fellowships, including $1.5 million for support of minority graduate students. The Foundation's priorities lie in graduate education and training as they relate to research. However, in elementary and secondary education, NSF can play an important, catalytic role by helping to identify certain critical needs, providing information on them and encouraging scientific and professional societies, academic institutions, state and local governments, private industry and other Federal agencies to meet the challenges of early preparation for research careers in science and engineering.

The potential national significance of this role is underlined by the recent establishment of the National Science Board Commission on Pre-College Education in Mathematics, Science and Technology. This Commission can give us a truly unique opportunity to accomplish three things. First, it can focus national attention on the problems and opportunities in pre-college education in science and mathematics. Secondly, it can work with State and local officials, scientific and professional societies, representatives from industry and from academic and educational institutions to examine the total dimensions of the needs in pre-college science and mathematics education and to suggest national, and I emphasize, not necessarily Federal, strategies for addressing them. Finally, it can identify the boundaries of a new consensus on what the role of the Federal Government, and of the Foundation, ought to be in these strategies. It is clear that the consensus which existed in the 1950's and 1960's on this role and the appropriate strategies to be pursued no longer exists.

Dr. Branscomb will now describe more fully the current status of our planning with regard to this commission as well as describe the general role which the National Science Board has played in establishing the priorities and shaping the judgments reflected in the FY 1983 budget request.

CONCLUSION

I would like to conclude my remarks today by saying that we believe the Administration's budget request for FY 1983 is a sound, strong one that will give us the maximum return for the dollars requested. Mr. Chairman, I want to stress that this is a parsimonious request in which we believe we have made a number of hard, but correct, judgments within the context of the President's economic recovery program, judgments which balance the many responsibilities fully recognized by the Foundation.

The funding requested in this budget will help us to continue to support much of existing science and engineering research in a number of areas crucial to our Nation's future; it will enable us to support many of the brightest, most promising graduate students in the Nation; it will send a strong signal to women and minority groups that they have a future in this Nation's scientific and engineering institutions; it will maintain the role which the national centers and oceanographic research fleet play in advancing fundamental knowledge in astronomical, atmospheric and ocean sciences; it will continue our important international cooperative activities and maintain our innovative efforts to encourage greater industry/university interaction in research.

Finally, on a more personal note, Mr. Chairman, I believe that the establishment of the NSB Commission on Pre-College Education in Science, Mathematics and Technology may be the single most important step which we will take during my time as Director of the Foundation. I am personally committed to the work of this Commission. I will consider it a privilege to come at any time to discuss with members of this Committee, either individually or collectively, the progress it is making, the problems it is encountering, the opportunities that we see and the results that we can expect.

The Commission is not being established for the purpose of conducting yet another study. It is being established for the purpose of developing an action plan that will produce preliminary results at the end of six months, more substantive recommendations at the end of twelve months, and a final conclusive set of results at the end of the eighteen-month anticipated life of the Commission. It will be a plan that identifies specific responsibilities of the National Science Foundation, other Federal agencies, state governments, local school districts, private industry, private foundations, and citizens at large.

We have the support of the Administration in this action: the support of the Office of Management and Budget; the support of Dr. Keyworth, the President's Science Advisor in the Office of Science and Technology Policy; the support of Secretary Terrell Bell of the Department of Education; and the full support of the National Science Board as evidenced by Dr. Branscomb's statement.

I urge you and the other Committee Members to support us in this exciting initiative for developing a new concensus and a new set of comprehensive plans for science and engineering education for the decade of the 80's and beyond.

Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. We are aware that the funding status in fiscal year 1983 for the Mauna Kea, Hawaii, infrared telescope facility is somewhat ambiguous--regarding whether the NSF or NASA has primary budget responsibility. Could you provide us a status on this issue?

Answer. NASA has primary budget responsibility for the infrared Telescope Facility (IRTF). It was built between 1976 and 1979 with NASA funds as ground-based support of NASA planetary space missions, in particular the Voyager encounters with Jupiter. In fiscal year 1982, the telescope's operation is funded by NASA's Earth and Planetary Exploration Division at $1,300,000 for 11 months. As a consequence of NASA's funding rationale, 50 percent of the telescope's observing time is devoted to solar system studies with the rest of the time available for other astronomical observing programs. In fiscal year 1982, NSF contributed $60,000 to support travel to the IRTF for obeervers carrying out non-solar system programs. Investigators supported by NASA grants constitute 70 percent of all users of the IRTF.

We understand that NASA has made no final decision on support of the IRTF in fiscal year 1983. The Foundation is strongly encouraging NASA to continue its support of the IRTF because of the importance of this facility for astronomical research and the fact that it is a major asset to the U.S. astronomical community.

Question. NSF is the "primary supporter of fundamental research in information science and technology" through the Biological, Behavioral and Social Sciences Directorate. This activity is level funded for fiscal year 1983. In light of the revolution that is occurring in the convergence of telecommunications and computers, isn't this an unlikely area to restrain?

Answer. The fiscal year 1983 budget request for the Information Science and Technology subactivity ($5.2 million) is the same as the fiscal year 1982 Current Plan. This is an emerging field of research and NSF expects to fund about 50 percent of the requests. The decision to limit funding for this subactivity was required to accommodate to the constraints on the fiscal year 1983 budget, and to maintain funding levels for the behavioral social and economic sciences which had experienced substantial budget reductions in fiscal years 1982 and 1983.

Question. To what extent could the decision of the private oil companies to pull out of the Ocean Margin Drilling project be attributed to the Federal goverment as an undependable partner?

Answer. That viewpoint does not seem to have been a signficant factor in the termination of the Ocean Margin Drilling Program (OMDP).

The major consideration in the decision of the ten supporting companies not to continue was the failure of the program to win support from a wider segment of the industry. All of the participants were feeling the effects of the softening oil market and the resultant drop in sales and profits. Even so, several companies were willing to continue if the costs and risks were shared by the industry as a whole. The economic problems of the oil industry not only made it difficult to keep the original coalition together, but made recruitment of new members virtually impossible.

The federal budget outlook for the 1982–84 period did have some impact on the termination decision. Last fall, it became clear that budget constraints would require stretching the *Explorer* design and conversion effort over several years. For those companies hoping for short term technological or scientific spinoff from OMDP, the delay was unacceptable. This concern was not universal among the ten supporting companies, however, nor did it arise from a view that the Federal goverment was an "undependable partner."

Question. What other countries participate in our ocean drilling program?

Answer. France, the Federal Republic of Germany, Japan and the United Kingdom are partners in the International Phase of Ocean Drilling. Each partner contributes $2 million per year to the Deep Sea Drilling Project, as well as participating in the scientific planning and execution of the program.

The Soviet Union was also an IPOD member country, but their participation has been suspended indefinitely as a part of this country's response to the Polish situation.

Question. Do they support your plan to modify the *Explorer?* Will they share any of the costs of modification of the vessel or operation of the program?

Answer. There is a great deal of international interest in the possible Advanced Ocean Drilling Program, both among the current partner countries and other potential participants. They are attracted by the science program itself as well as by the enhanced capabilities offered by the *Explorer.*

As a practical matter, participation in the current DSDP is limited by the size of *Challenger,* which rules out any significant expansion of international representation in the scientific crew. *Explorer,* on the other hand, could accommodate much larger scientific complements, which would enable us to expand the number of member countries without diluting the benefits of participation.

Assessing the level of potential international support is a major element in our planning for AODP. Because the *Explorer* program is still under review by the Administration and the Congress, we have not yet been able to discuss the proposal in other than general terms. Several countries are prepared, in principle, to contribute significantly to the operating costs of the program, but levels of support have not been officially discussed.

Some "payment-in-kind" is also a possibility in equipping and outfitting the *Explorer,* since some of the desired ships systems and scientific instruments are of foreign manufacture. As a matter of policy, however, we would not wish to dilute U.S. ownership of the ship by applying foreign funds to the basic conversion of the vessel, nor does it seem likely that our international partners would wish to have their funds used in that way.

Question. At what point do you anticipate that the science plans for ocean drilling will require a decision on further upgrading of the *Explorer* to include riser drilling configuration?

Answer. Our present plans for AODP are predicated on use of the *Explorer* without a riser. The geological and geophysical community has already designed an

eight-year riserless drilling program. There seems no doubt that there is ample scientific justification for a decade or more of *Explorer* drilling in this mode.

However, the scientific objectives that underlay the Ocean Margin Drilling Program are still valid, and it is reasonable to expect that at some time, consideration should be given to adding the riser capability. The basic conversion design incorporates specifications for a full riser, so that it could be added in the future at minimum cost.

Question. Is there any prospect that the private sector may rejoin the project and possibly share the costs of any required upgrading?

Answer. In the short term, probably not; although it should be noted that many industrial scientists and engineers have continued to work with us in planning for the AODP.

Over the long run, an arrangement with industry to develop and fabricate the riser, in return for use of the *Explorer* for a specified period, might well be negotiated.

Question. You have stressed the importance of "international scientific exchange and cooperation," even though the NSF has proposed eliminating support for U.S. participation in the International Institute for Applied Systems Analysis (IIASA) and elimination of the International Travel Grant program. Is this consistent?

Answer. NSF continues to stress the importance of international scientific cooperation. In fact, this topic is being considered as the subject of the next annual report of the National Science Board. The proposed elimination of support for U.S. participation in IIASA followed careful deliberation of funding priorities. Fiscal year 1983 was NSF's first opportunity to withdraw from membership following the 26.6 percent budget reduction for International Cooperative Scientific Activities between fiscal year 1980 and fiscal year 1981. In fiscal year 1981 and fiscal year 1982, IIASA dues were by far this subactivity's largest single budget item, making up more than 20 percent of its total budget.

Experience indicated that greater benefits to the U.S. research effort generally are achieved through the participation of U.S. scientists and engineers in a range of carefully selected and managed bilateral agreements with other countries than through participation in IIASA. More scientists and engineers can participate in more subject-matter areas and can benefit from a variety of overseas sites, facilities, opportunities for scientific collaboration, and cost-sharing arrangements through bilateral cooperation than through more highly specialized arrangements such as IIASA. Cooperation through IIASA is also less economical because the U.S. and the U.S.S.R. bear a disproportionately high share of IIASA's cost.

Under the current economic situation, stressing bilateral programs and eliminating support for IIASA is the cost-effective route consistent with NSF's objective of strengthening the U.S. research effort through international scientific exchange and cooperation. Moreover, subsequent to NSF's decision, the President determined that further participation in IIASA is not in the U.S. national interest.

Even though the line item for the International Travel Grant program was eliminated, proposals for travel funds are now accepted for consideration by NSF research and engineering programs.

The intended effect of both decisions is to focus International Cooperative Scientific Activities on bilateral arrangements to strengthen the U.S. science and engineering effort where the greatest benefits lie.

Question. Is consideration being given to picking up any of the basic research of EPA as that agency moves toward eliminating research that is not directly affecting its regulatory and enforcement programs?

Answer. Reductions proposed by EPA in the University Research Grants Program may result in an increased number of proposals to the Foundation, particularly in areas such as ecosystems studies, environmental engineering, and atmospheric and ocean sciences. At this time, it is not possible to estimate the number of such proposals, the dollar amounts involved, or the timing of proposal submissions, if any, to the Foundation.

The Foundation will continue to consider proposals for basic and applied research that EPA will not be able to support. All such proposals would have to compete with all other proposals in the specific field or discipline and would receive the usual thorough peer review to evaluate scientific and technical merit. NSF does not intend to provide sheltered funds for such proposal or to give them preferential treatment.

Senator SCHMITT. Dr. Langenberg?

STATEMENT OF DR. DONALD N. LANGENBERG, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. LANGENBERG. Thank you. Let me take a few moments to characterize the general nature of what we see as another large and serious problem.

Over the past few years the Foundation has placed a high priority on upgrading scientific and engineering research instrumentation in the nation's colleges and universities.

Why have we done so? A well-established consensus in the university research community, the Federal Government and private industry holds that a critical and growing need exists to replace obsolete and worn-out research instrumentation and laboratory facilities in the Nation's research universities.

It is difficult to be precise about the size of the problem. Still there is qualitative but strong evidence that it is pervasive and quite large in scope. A rough but reasonable estimate of the lower bound of the deficit is about $1 billion. Upper bounds have been placed near $3 or $4 billion.

Let me emphasize that I am talking about deficit; that is to say, about what it would take to get us back to a functional state-of-the-art level.

If this assessment of the nature and scope of the problem is correct—and we think it is—it means that the productivity and efficiency of the Nation's academic research enterprise relative to what it should be have declined and probably will continue to decline.

Most of modern science and engineering research is highly instrumentation dependent. Capital investment in instrumentation and the facilities needed to support it are critical, if this country is to maintain a position at the forefront of a wide variety of disciplines and to obtain maximum productivity from dollars invested for research.

Clearly we need to know more about the nature and character of the problem. NSF is exploring the development of a system of indicators on the status of instrumentation in research laboratories—to give a better and continuing picture of the problems. We have preliminary data obtained last fall in a sample of 38 institutions. It suggests that about a quarter of all research instrumentation holdings are 6 to 10 years old, and another quarter are more than 10 years old. We also find that shared use of instrumentation among researchers and departments is very common.

Even though considerable work remains to be done, can be done, will be done, to get better information about the problems, some immediate action has been taken. I would like to discuss a couple of actions taken during the past year.

Last August, with the strong support of the Director of the Office of Science and Technology Policy, Dr. Keyworth, NSF convened an interagency working group on university research instrumentation. Its purpose was to begin reviewing the nature and extent of the problem and to explore what schemes might be available for a possible Federal response. Apart from the NSF, representatives from Agriculture, Defense, Energy, NASA and the National Institutes of Health participated.

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The working group looked at the available information and concluded that inadequate university research instrumentation is indeed a pervasive and an endemic problem, and that the Nation would benefit from its alleviation. Because of the diverse mission responsibilities of the participating agencies, the group concluded that an approach involving coordination and exchange of information, rather than one seeking to devise a monolithic Federal program to attack the problem, would be preferable. Such a strategy facilitates matching individual agency priorities, assessing their relationship to other research requirements, and enabling better responses to special needs in different scientific areas. Some results of the group's meetings are evident in the fiscal year 1983 budget and in the procedures and practices which the participating agencies are beginning to follow. You will find in the fiscal year 1983 budget of the Department of Defense a $30 million initiative to build a university research base for disciplines related to its scientific programs. That is intended to be the precursor of a $30 million per year program for 5 years, making a total of $150 million. Those responsibilities are being shared equally among the three OXR's, the RO, the FOSR and ONR.

NASA is having its program officers give special attention to project-related instrumentation requests. NIH plans to increase slightly its current instrumentation programs. Energy plans to instruct its program officers to protect budgets for instrumentation in its research awards. And NSF research programs are increasing their support for major equipment and other instrumentation by 11.5 percent over fiscal year 1982 to a total of $95.3 million.

We expect that the interagency working group will continue to monitor, coordinate, and heighten awareness of the problem.

Within the NSF budget total, each scientific area in the Foundation is responding to the particular needs in instrumentation for its discipline. Increases for equipment and instrumentation relative to fiscal year 1982 range from 4.8 percent in the Antarctic program to 23.5 percent in engineering.

In addition to the plans for enhancing instrumentation in the several programs that Dr. Slaughter discussed, funding for research instrumentation for faculty at 2- and 4-year colleges will be continued in fiscal year 1983. The program has been successful in supporting small research equipment acquisition at such institutions and in upgrading thereby the research capabilities of their faculties. But this year, rather than proposing a separately identified budget line for the program, NSF will provide support for such instrumentation in the relevant research directorates in order to maintain close contact with the scientific disciplines.

You will find in Dr. Branscomb's statement, submitted for the record, mention of an authorization by the National Science Board to the Foundation staff to explore alternative means under the new tax law for stimulating charitable contributions of research equipment by manufacturers to universities. We have begun discussions with manufacturers, to test the waters, and we find that although they are generally aware of the relevant provisions in the law, they are still undecided about how extensively they will use it. In part, they appear to be awaiting the issuance of regulations by the Treasury Department—to see exactly how the system is going to

work and what the incentives really are. We plan to continue exploring ways to stimulate, to the maximum extent possible, manufacturers' use of those provisions.

Senator SCHMITT. Has the Treasury indicated the date for the issuance of those regulations?

Dr. LANGENBERG. They are working on them, and NSF, among other agencies, has recently commented on them. I do not have any idea when the regulations will be issued.

Senator SCHMITT. Another "check is in the mail" story, I guess.

Dr. LANGENBERG. In concluding, I want to emphasize that while these activities will certainly not eliminate the need for continued effort toward a major renovation of advanced scientific research and engineering instrumentation, we think they do represent a realistic and meaningful approach at a time when economic recovery is a national concern.

What has been done by the Foundation in fiscal year 1982 and what it is proposing for fiscal year 1983 calls attention to the need for continuing effort in this area, provides a good balance across areas of science and engineering, meets some of the most critical research needs within a constrained budget, and allows for the exploration of new ways of providing the instrumentation essential to full use of the Nation's scientific and engineering manpower.

Thank you, Mr. Chairman.

Senator SCHMITT. I guess the bottom line, Doctor, is still that we are losing ground.

Dr. LANGENBERG. Yes, sir, we are losing ground.

Senator SCHMITT. Do you detect—I'll give you a toughie, maybe. Dr. Slaughter, do you detect any awareness of any significance of the role that science and technology has played in our past and will obviously play in our future, within the circles that you negotiate your budget?

Dr. SLAUGHTER. Yes, I certainly do. During the past year, positive activities have occurred between the Foundation and OMB and the Office of Science and Technology Policy. If that were not so, I am sure the NSF budget would not be nearly so strong. I am encouraged, and I believe the activities will continue to develop and flourish.

Senator SCHMITT. But at least on two occasions this morning, the two of you have indicated that we have not turned the corner yet. If we have not turned the corner and our investment in instrumentation and education and in some critical basic science insights are still deteriorating, then why should this committee or the Congress or the American people think that there is an awareness of the critical nature of science and technology as the single most important edge that a free country has in its own protection?

I am not talking about protection through national defense systems so much as I am through protection of society. Freedom protects itself if it has an environment in which the ideas and inventions of free people can be examined and tested, and bear fruit. What we have destroyed, to a large degree in this country, through regulation, taxes, and a lack of perspective of just what the Federal role should be in these areas, is the environment in which freedom can prosper and protect itself.

Do you really think that kind of insight exists at the present time in the upper levels of OMB and the White House?

Dr. SLAUGHTER. I think such insight resides there. The problem is simply that turning the corner, as you put it—correcting problems so complex, and so embedded—will require more than a year's initiative. It will require the kinds of major financial commitments that would produce distortions in other parts of the budget. We simply must recognize that so long as the economy is in recession, we will not to be able to turn the corner in a short time. But the trend is in the right direction, and there has been a——

Senator SCHMITT. You mean the rate of decline has decreased?

Dr. SLAUGHTER. Yes. And in some cases we have begun to come back. The serious problem of instrumentation, results in part from failure to define the range of needs. We know there is a problem, but it is difficult to get agreement upon its magnitude. Consequently, it is very difficult to identify what represents the solution or only a partial solution. Still, there is a sensitivity to the problem. We in the agencies must come up with better efforts to convey the level of the problem to OMB.

Senator SCHMITT. Doctor, again, do you really believe that there is that sensitivity at the level where the final decisions are made on the budget with which you must live and, to a large degree with regard to science and technology, decisions with which the Congress must live—because we are not going to introduce major new policy innovations here in the Congress. There isn't the awareness over here of the importance of science and technology to do that, and the history of science and technology legislation clearly proves that.

Do you believe, that in those people making the decisions, there is really an awareness that the ultimate solution to health care problems is the prevention of disease or absolute cure of disease and injury if it occurs; that the ultimate provision of food and clothing and housing for the disadvantaged in our society is through innovative low-cost means of providing better food, clothing and housing than we have today? Or that the ultimate protection of our natural environment is through the application of science and technology? And the list is far longer than one would have time to outline under any circumstances.

But do you think that they really recognize that is where the solutions are? Or is it merely a response to a few squeaky wheels like yourself and maybe myself?

Dr. SLAUGHTER. Senator, it would be unfair for me to say there is the same level of understanding that you just expressed.

Senator SCHMITT. Well, what does it take, Doctor? All you have to do is read history. Don't we read history any more? I think there are not very many milestones in the history of the United States that do not relate directly to the application of the science and technology base produced by free Americans.

The founding of this great land might seem to be one of those nonscience and technology milestones, except if you examine it very carefully. Then you see that we never would have been here or been successful if it had not been for the base of science and technology that existed, as well as the dedication and sacrifices of those early Americans.

Certainly there are other examples, but when you look at the major milestones, for which this country is noted, and the history books record, they rise from a base of science and technology.

Dr. SLAUGHTER. It takes persistence; it takes persons like yourself willing to speak from your platform; it takes dedication from the agencies. But it also will take a stronger recognition by the people—the guys paving the streets and doing the plumbing and teaching in the schools and working in the banks—to make the impact we are talking about.

That is why we find ourselves in a dilemma. People must have greater confidence that we are spending public resources in ways to address the problems, and that confidence is lacking. It is not something any of us can expect to turn around this year or next.

Senator SCHMITT. Can you briefly illustrate how the NSF programs are aimed at developing the general scientific and technological literacy of our population, beyond that what is necessary to insure that the right number of scientists and engineers are coming out of the pipeline of university education?

Dr. SLAUGHTER. I can provide an answer for the record. Certainly NSF's science education programs are designed to assist those young people who may become the next generation of scientists and engineers.

The programs become more important when the Department of Defense reports it needs persons with enough technological capability to operate modern-day equipment.

NSF also has provided support to museums, to media presentations on science and mathematics, and to libraries and public facilities supplying literature and information about science. It should be a part of the rethinking about NSF's responsibilities in science education.

Senator SCHMITT. I hope you will expand for our record on the general issue of science and technology literacy and how the NSF programs are relevant, because it is ultimately the electorate who must make the decision on what we do, and if the electorate does not have a basic understanding it is going to be very difficult for us to see legislative action in the long run that begins to solve some of these basic problems.

[The information referred to follows:]

Question. Please expand on the general testimony regarding the impact of NSF programs in the general scientific and technological literacy of the population.

Answer. Although most NSF efforts in science and engineering education have been directed toward the development of professional scientists and engineers, there have been efforts to provide support for the general understanding of science and technology through the science and Engineering Education activity.

Two audiences have been addressed:

Future scientists, engineers and technicians—Unless children receive early experience with mathematics and science, and unless they are exposed to the excitement and satisfaction of such activity, they tend to avoid "difficult" subjects like mathematics. This so-called "math-avoidance syndrome" results in decisions that effectively preclude later pursuit of important and rewarding careers and interests. The problem is particularly critical for women and minorities.

Adults—Few persons in this country receive extensive education in science and technology. Although there is wide, popular interest in science and technology, a recent study indicates that only 6 percent of the population understands the general nature of scientific activity. The implications of this lack of understanding are important to public and industrial decisions, and to popular support for these decisions.

The following examples provide an indication of the impact of NSF efforts.

The Outdoor Biology Instruction System (OBIS) is a program of science experiments to teach outdoor biology to young people in the 11 to 15 year old range. It is intended mainly for use by youth programs outside the school setting, such as Boy and Girl Scouts, 4-H groups, and community activities, although it is used in school programs too. The units have been designed to allow individuals with little or no formal background in the natural sciences to help groups of young people to observe ecological interactions and relationships. Equipment needed is simple and inexpensive. It was developed at the Lawrence Hall of Science in Berkeley, California, and is now used throughout the country.

The children's TV series "3-2-1 Contact" is broadcast twice daily and continues to have a very large audience of 8-12 year olds despite the fact that it is now in its fifth rerun. In its first season alone, the series reached 23 million at-home reviewers—including 6 million homes without children. In addition, it was seen by roughly 3 million children in school, and over a third of a million teachers guides were requested. Subsequent reruns have, of course, greatly enlarged this initial impact. In addition, the Girl Scouts have initiated a new program of science badges based on the program and a number of science museums have developed weekend programs capitalizing on the series.

The "NOVA" television series now reaches almost 10 million viewers each week and has served as a model for other science programs and publications. Its success has encouraged a number of magazine publishers to enter the science field.

The "Exploratorium" science museum in San Francisco is a unique center for hands-on experience by children and adults—visited by over a half million persons per year. It is recognized as one of the world's outstanding science museums and has been a model for exhibits and activities in many other centers. NSF support has played a key role in its development and in developing the "cookbook" designs that are copied by other museums.

Other projects have worked through zoos. A final example of activities in this area is a program at the University of Colorado to involve older students and senior citizens in the interdisciplinary nature of scientific inquiry.

Dr. LANGENBERG. I would like to point to Science Indicators 1980, the NSB report which analyzes, among other things, a public opinion poll that NSF undertook. It suggests that a large fraction of the population puts science and technology high on its list of potential solutions to problems faced by this society.

It probably would be unfair to claim that that belief is in most cases well founded on understanding and appreciation. But that belief does appear to be there, and the electorate does appear to have a considerable faith in the ability of science and technology to help cope with the society's problems.

Senator SCHMITT. I have seen similar results, and I agree with you. It is fascinating that the electorate in any survey that is objective and properly run shows that they believe basically that the greatness of the United States is in large part due to our science and technology. But for some reason that Jeffersonian perception, if you will, does not translate into the political process. And that is the link that I do not see as being present right now.

I have my own ideas on why it is not there, but nevertheless it does not seem to be present.

You have mentioned several areas relative to education, fellowships, instrumentation and facilities, university-industry cooperation, research awards, for example, in which we are underinvesting or have reduced our involvement substantially from only 2 years ago.

In Dr. Branscomb's testimony it is pointed out that "the Foundation should and will seek to encourage private companies to expand their participation in university research."

Now, Dr. Slaughter, if additional funds were available for some or all of the areas mentioned, would it be appropriate that their award be contingent on matching funds from private industry?

Dr. SLAUGHTER. It is an appropriate topic to pursue. As a matter of fact, NSF is pursuing it. The industry/university cooperative research centers are based upon joint support from industry and the Federal Government.

In several areas you have mentioned—instrumentation, fellowships, even support for students, faculty—it is appropriate and certainly possible to examine how part of the support can be provided by the private sector. NSF has encouraged communication between a consortium of industrial organizations, the NSF staff, and other Federal agencies to examine such opportunities, within safeguards to protect industry, Government and the recipients.

I am encouraged that initiatives are being suggested by the industrial participants. I take them as positive signs.

Senator SCHMITT. I have a great number of very good friends in the academic community, the research community, who since I was in college and university, have become extraordinarily inventive, clever, in how they pursue Government grants.

Don't you think that if we made at least some category of those grants contingent on the application of comparable inventiveness and innovation to obtaining matching funds from other sources, that we would be able to tap a much broader base of resources in the country than we do today?

Dr. SLAUGHTER. I certainly think it is possible; requiring it must be done with care. But it is certainly true that the creativity of persons seeking support can bring about opportunities no one could have imagined.

Senator SCHMITT. When I was in Cal Tech, 1953–57, most of the funds for research, at least in the Earth sciences, were private sector funds. Today it is just the opposite. The pendulum has swung all the way over as a result of easy access, and I think frankly, of faculty pressure within the research institutions to get rid of industry money as dirty money. And maybe there was cause at times for that to be believed. I will not editorialize.

But, nevertheless, that transition happened just as I was moving through graduate school. The belief on the part of faculty was that industry money was dirty money, and that graduate students should not be supported by such dirty money. It was a tremendously difficult period for graduate students during that transition period. I was fortunate to have had a mix, to be able to survive it. But others had a difficult time.

Do you see that attitude within faculty and university management as having changed?

Dr. SLAUGHTER. Your historical account is apt, because about that time the Federal Government began to provide more support. It was fairly easy for persons to say, "We no longer want to depend upon industry because this other opportunity is available."

Now the rate of increase of Federal dollars has declined in many disciplines, and researchers look to the future with trepidation. Support from industry and others has become a more attractive alternative.

There still are concerns about patents and publications, but certainly there is a greater willingness among faculties and university researchers to consider support from entities other than the Federal Government.

Dr. LANGENBERG. There are strong indications that the pendulum is beginning to swing back. The subject of industry-university cooperation, of research cooperation, and of possible funding by industry has probably been one of the hottest topics of that community for the past 2 or 3 years. Increasingly, words are beginning to be replaced by action.

You will hear faculty members say, "Wouldn't it be wonderful to get industrial money which won't have all the bureaucratic redtape attached to it?" And they are not talking about dirty money, they are talking about non-redtape money.

Historically, many of our programs have had significant matching requirements. Often in equipment programs, matching has been required.

Senator SCHMITT. Do you think it would be appropriate for the subcommittee to consider, at least an experimental program of matching grants in augmentation to current grant programs?

Dr. SLAUGHTER. I would certainly not think it inappropriate to examine that, and I would hope that the subcommittee, if it is interested in pursuing that, would allow us to work with you in thinking through how that can be accomplished.

Senator SCHMITT. We would not only allow you, we would encourage you. And if you would like to supply for the record and have your staff meet with mine, we will begin to look and see if that might be appropriate.

I think it also might be appropriate in some other areas, such as at NIH, where we are seeing the number of grants reduced because of reduced budgets. Maybe at the very least an experimental program is appropriate this year, to see what the response is, to see what bugs develop. But a much broader implementation of improved programs next year might be well worthwhile.

[The information referred to follows:]

Question. Explore the pros and cons and structure of experimental research support programs involving joint Federal and industrial funding.

Answer. The NSF has experimented with several research arrangements involving joint Federal and industry funding beginning with the Experimental R&D Incentives Program (ERDIP) in 1973. The Erdip experiments were evaluated by the Denver Research Institute and Research Triangle Institute between 1975 and 1979, and have influenced the current structure of two joint NSF/industry programs: Industry/University Cooperative Research Centers and Industry/University Cooperative Research Projects. These programs are subject to ongoing internal assessments.

The advantages of cooperative funding are basically two-fold: a better knowledge base for applied industrial research, and increased levels of support for university research. The differences between university research and industry research have become more marked in recent years. Industry seems to emphasize short-term research projects with direct market payoffs, while universities emphasize long-term research projects. The NSF cooperative centers and projects seem to have been able to bridge the gap by concentrating on those technical areas with strong common university and industry interests. The extent of the gap influences the cooperative mechanisms selected. It has been found that both university and industrial participants in the projects program tend to have little prior experience in each other's sector, and the projects program seems to provide an effective arrangement for increasing the linkage. Center participants, by contrast, tend to have a wider range of experience before entering the center.

NSF's strategy has been to phase out its support of a center over a three to five year period as industrial support grows. To date, the reduction of NSF funds has been more than offset by an increase in industry support. One measure of success is that all six current centers are moving toward full funding from industry. The MIT Polymer Processing Program now operates exclusively with industrial funds. Two other centers established subsequently have over 70 percent industrial funding, two are over 60 percent and one is over 50 percent.

The pattern of gradually phasing in industry support allows firms to have clear evidence of success before they are asked to make large investments. Centers are complex administrative undertakings, and there are relatively few precedents in either universities or industry to guide their evolution. There is a necessary learning period, and the administrative development of Center structures and processes is frequently as complex as the unfolding of the technical subject matter itself. NSF provides needed support during the developmental phase. Demand for centers by both universities and industries is growing at a rate that far exceeds even the most optimistic estimates of future NSF resources. NSF is currently developing a "Center Cookbook" to assist in the establishment of centers.

The success of individual centers is demonstrated by increasing industry and university involvement in center activities and expressions of the utility of the results of research to industrial participants. Centers are potential sources of new researchers; graduate students who participate in center projects become familiar with industry research interests and may, after they finish their training, enter the industries involved in the centers. For the universities, one advantage is increased resources for research. Provision of special scientific facilities and equipment helps universities to attract and keep talented scientific and technological faculty researchers. The centers, thus, serve the interests of both parties, although in different ways.

Individual cooperative research projects have also proven successful in bridging the gap between university and industry research interests and priorities. Specific projects within this program tend toward the "basic" side of the research spectrum. Industry involvement appears to be focused on general support of the knowledge infrastructure rather than on specific payoffs. The nature of the interaction may be inferred from an example. Scientists at Stanford, Cal Tech and the Hercules Company have discovered a new catalyst for oxygen-reduction electrodes to be used in hydrogen-oxygen fuel cells. Collaboration with university scientists provided a theoretical framework to the research, accelerating the discovery of the catalyst which may become the basis for new products eventually.

The disadvantages of joint Federal and industry funding for university research are potential loss of academic freedom and narrowing of the research perspective. This remains largely a matter of belief and worry; no empirical evidence either confirms or disproves this hypothesis. Some studies suggest that scientists are usually more concerned with maintaining control over how research is carried out than with what they work on or how research is evaluated. The potential loss of "freedom" has not been a concern in existing centers and projects, but the long-term effect on the research perspective of university researchers remains to be assessed. Universities need to allow centers a large measure of fiscal and administrative autonomy to achieve maximum benefits. Private universities, accustomed to such autonomy in their units, tend to have more cooperative projects than do public universities.

The difficulties of serving clients from different organizations and environments, the inexperience of most university scientists in managing large research programs, and the increased funding uncertainties which typically accompany industrial support are also sources of concern. How well the research director or principal investigator is able to balance individual and program goals and how well the university is able to accommodate and reward participation in joint research efforts are critical to success. In the centers in particular it has been found that the leadership behavior of the principal investigator is crucial, since university researchers in both cooperative projects and centers tend to be tenured senior faculty.

Problems for industry, thus far, seem to center around the costs and benefits of their participation relative to the costs of funding research within their own organizations. Costs to industry, while relatively modest, are seen as barriers to participation in university research only because the outputs of the research are not exclusively appropriable. The companies involved tend to have already significant R&D programs and substantial slack resources.

These programs should not be seen as permanent ends in themselves, but as a means of learning about costs and benefits of different approaches as models for university, industry, and government participants. NSF's initiatives explore differ-

ent kinds of technological areas, different administrative mechanisms, different funding patterns, and different kinds of accountability mechanisms. They should be carefully evaluated and lessons distilled for future application through systematic assessment and background research on university/industry cooperation.

NSF sees the major thrust of the next few years in the university/industry cooperative research area as largely one of learning from the existing programs as a basis for the development of new concepts and institutional forms that permit universities and industry to make better mutual use of their unique capabilities. The cooperative projects program provides a broad and relatively decentralized framework applicable across many different fields of science and technology. The cooperative centers, by contrast, concentrate on those fields of science where the direct payoffs from cooperation are seen as substantial and the problems are more those of application.

Senator SCHMITT. We will have some questions for the record, to get some specific estimates on numbers and amounts of awards and amounts and things of that nature.

Dr. Slaughter, in the industry and university cooperation research program, what has been the most significant accomplishment under this program at this time other than the spinoff of the centers? Your testimony mentioned several items. Is there anything else the subcommittee should be aware of?

Dr. SLAUGHTER. A feeling is developing that universities and industries can collaborate without either becoming tainted. Positive benefits can result. University researchers can be supported and progress made toward solutions of technological issues with interest to industry. And specific areas of quality research—which would be competitive in any environment—are supported by joint mechanisms. The latter is probably the major payoff, in addition to scientific breakthroughs. We are working ways for joint support of the type we talked about a few moments ago.

Senator SCHMITT. Why is the total activity going to be funded at $6 million, well below the $9.5 million from the 1982 amended request?

Dr. SLAUGHTER. The $6 million is confusing; it will be double that amount. $6 million is contained in a particular category; another $6 million is provided for the specific discpline in which the research is done. The actual level is $12 million.

Senator SCHMITT. OK, I am glad we cleared that up. So actually the effort itself is going to see a significant increase?

Dr. SLAUGHTER. That is correct.

Senator SCHMITT. Do you see any indications that industry is reluctant to make full responsibility once the seed funding period is over?

Dr. SLAUGHTER. Some industrial organizations were hesitant, but in chemicals and electronics, where most of this activity has taken place, the companies are beginning to remove any doubts.

Senator SCHMITT. Are any of those doubts a result of the conditions that you set for industry participation?

Dr. SLAUGHTER. The conditions are largely set by the university. NSF merely plays the role of marriage broker; we try not to legislate.

Senator SCHMITT. Unarmed marriage broker?

Dr. SLAUGHTER. Right; keep it going without any arrows.

Senator SCHMITT. You proposed for fiscal year 1983, $15 million for NSF graduate fellowships and minority graduate fellowships. This is the same level as fiscal year 1982. How many students will be supported under this budget compared to 1981, for example?

Dr. SLAUGHTER. We have increased the stipend slightly. The number of students supported is about 1,500?

Dr. LANGENBERG. There will be 500 new awards in fiscal year 1983, of which 50 will be minority graduate fellows. The total number of students will be about the same as in the recent past: About 1,400 students.

Senator SCHMITT. These are competitive fellowships?

Dr. LANGENBERG. Yes. They are awarded to individuals, and the students may take them to any institution they wish.

Senator SCHMITT. Including abroad?

Dr. LANGENBERG. Yes. Very few ever do go abroad, because the opportunities in this country in the major research institutions are exceptional. I do not know of any instances in which the students have gone abroad.

Dr. GILLESPIE. I think we should check that for the record.

[The following information was subsequently received for the record:]

Question. Are any of the NSF graduate fellowships "portable" outside the U.S.?
Answer. Yes. NSF graduate fellowships are tenable at any non-profit U.S. or foreign institution of higher education offering advanced degrees in science or engineering. A very small number of fellows actually use their fellowships outside the U.S.; less than a dozen in any given year (out of a total of 1,400–1,500 fellows) do so and no additional funds for travel allowances are provided.

Senator SCHMITT. I would appreciate that.

I remember back in 1957 I ran into a situation where I had been awarded an NSF fellowship and a Fulbright, and I was told at the time, and I believe, incorrectly, that I could not take the NSF abroad.

Dr. LANGENBERG. I think that was incorrect.

Senator SCHMITT. As a result, I was never able to get an NSF fellowship, having turned you down.

Dr. SLAUGHTER. Do you want to apply to us to correct that?

Senator SCHMITT. Well, I got a post-doc, so that was all right.

How do these fellowships compare in size and number with those available elsewhere, particularly with other Federal agencies?

Dr. SLAUGHTER. Actually, they are not nearly so competitive as we would like. The Department of Defense is initiating a program in which a total of $20,000 per award will be provided, $12,000 for the student and $8,000 for the cost of instruction, as compared to NSF's award of about $7,000 and $4,000.

We believe that we need to improve the stipend level for the NSF fellowships to make them competitive and to encourage persons to enter fields like engineering and computer sciences where there are more severe needs.

Senator SCHMITT. Are there any arguments for developing uniform grant awards across Government agencies?

Dr. LANGENBERG. You mean a uniform fellowship award?

Senator SCHMITT. Yes, I am sorry, fellowship award. That one slipped by me completely. I did not realize that the Defense Department award was a total of $20,000 and your total is $11,000.

Dr. SLAUGHTER. Our total is about $11,000, that is right.

Dr. LANGENBERG. The total is increased from what it was 2 years ago, $4,800 rather than $6,900 for stipend. But it is not up to a truly competitive level. We recognize the need to push it up further.

Senator SCHMITT. Well, that is going to cause some significant skewing, is it not, of where the best, most competitive young people

will go? They will obviously opt for the higher fellowship of the Defense Department, will they not? Or many of them will. Some may not.

Dr. LANGENBERG. That may be the case. The Defense Department's fellowships were focused to some degree in scientific and engineering areas of most relevance to the Defense Department mission. And one of the obvious reasons for the relatively large size of the Defense Department stipend and institutional allowances is that many of those fellowships are expected to be won by engineering graduate students. In engineering, competition has driven fellowship, teaching assistant, and research assistant levels to significantly higher levels than in many of the sciences.

Senator SCHMITT. But you have the same level for both engineering and science.

Dr. LANGENBERG. Yes, we do. We have considered whether the policy should be continued.

Senator SCHMITT. If you would like to expand on your thoughts, your present thoughts for the record, you do not have to take a position for the record, but it would be helpful to the subcommittee to have your thoughts to ponder.

Dr. LANGENBERG. We would be glad to do so.

Senator SCHMITT. And also the pros and cons of having grant awards run uniform across the Federal Government both for individuals and institutions. And too, that if there should be a difference between engineering and science, should that difference be uniform across the Federal agencies?

Dr. SLAUGHTER. We will provide that

Senator SCHMITT. Do you know what proportion of graduate students in science and engineering receive NSF graduate fellowships?

Mr. KAGARISE. There are about 5,000 total Federal science and engineering fellowships and the NSF provides about 1,400. So that is about it. Our emphasis, of course, is in the national competition and on quality. We had not pursued quantity, large numbers. The emphasis is on the selection of very high quality students for graduate work.

Dr. LANGENBERG. We could provide you more accurate numbers for the record. There are several thousand graduate students in science and engineering across the country. NSF's fellowship number is about 1,400.

[The information referred to follows:]

Question. What proportion of graduate students in science and engineering receive NSF graduate fellowships? What proportion of graduate students in science and engineering receive student assistance on NSF grants? What proportion of graduate students of science and engineering receive student assistance on other Federal agency research grants? Is the proportion of students supported by the NSF increasing or decreasing?

Answer. In 1980 there were approximately 383,210 full- and part-time graduate students enrolled in science and engineering advanced degree programs. Of these the 1,500 NSF Graduate Fellowship holders were about 0.4 percent of this total. In addition, in 1980 there were an additional 7,760 graduate students receiving assistance through NSF research grants (approximately 2 percent). Other Federal agencies supported approximately 21,500, about 5.6 percent of the total, graduate students in science and engineering through research grants in 1980. The NSF proportion of such students appears to be steady (about 2.5 percent) and no major shift is anticipated.

Question. Should all federally-supported fellowships—those of NSF as well as those of the Department of Defense and other Federal agencies—carry uniform stipends and cost of program allowances?

Answer. This is very difficult to answer from a single agency's perspective. Each agency has a different overall mission to accomplish and uses fellowship programs in different ways to carry out their goals. Fellowship stipends and allowances can reasonably vary with the purposes of different programs and with differing conditions on awards (e.g., restrictions on supplementation). Some are nationally competitive, others are not. Some agencies offer support in a limited disciplinary area, others, such as NSF and NIH, have a broad support area. Some allow outside supplementation of fellowship funds, others do not. This is a question which needs in-depth study and discussion before a definite recommendation can be made.

Question. What are the implications of setting differential support levels for fellowships of various disciplines?

Answer. The stipend for the NSF Graduate Fellowship Program is integral to the purpose and design that are currently derived from the NSF Act (P. L. 81-507, Section 10). The Act stipulates ability as the sole criterion for selection as an NSF Graduate Fellow, with geographic distribution as a factor in cases of substantially equal ability. Differential stipends would deviate significantly from existing purpose and practice and probably require separate programs for the various disciplines. Because of the timeliness of this issue, the National Science Board has requested a more thorough analysis of the issue, particularly as it relates to engineering.

Senator SCHMITT. We will ask more questions along that line in the record rather than use the time now.

Have you seen any turnaround in the last year or two that you can detect in the proportion of U.S. citizens in graduate school relative to the proportion of foreign nationals?

Dr. SLAUGHTER. In engineering, the problem is becoming more severe. At the graduate school level, of the numbers of foreign students enrolled in engineering Ph. D. programs are increasing largely because of accelerating salaries for undergraduate engineers, particularly in electrical and chemical engineering. There is less incentive for America students to enter gradueate school

Many institutions are beginning to restrict enrollments of foreign students, although the schools are caught in a financial bind. They cannot operate graduate programs with inadequate numbers of students, but they are concerned about a larger than desirable number of foreign students.

Dr. LANGENBERG. One of the NSF divisions developed some statistics in an effort to understand the growing concern about an increasing proportion of foreign graduate students in a particular discipline. It turned out that the total number of foreign graduate students in that discipline was not increasing. Instead, the total number of American women students had shown a significant upturn in the past 2 or 3 years, but the total number of American male students had been declining steadily during the past decade. And therefore, the increase in the proportion of foreign students was due simply to a decrease in the number of American male graduate students. That may be true only of the particular discipline, but it may be more general.

Senator SCHMITT. Do we have an explanation for the decline in number of U.S. male students?

Dr. LANGENBERG. A possible explanation is competition from other professional careers and competition from industry as opposed to graduate school.

Senator SCHMITT. Competition is not affecting women?

Dr. LANGENBERG. The number of women in most scientific fields has been very, very small. A significant upturn can be a very small number of women.

Senator SCHMITT. Absolutely.

NSF established 14 regional instrumentation facilities between 1977 and 1981. The funding peaked at $5.5 million and then decreased thereafter; that is, after 1979.

What were the limitations which developed in this approach to providing access to major state-of-the-art instrumentation for widespread users?

Dr. LANGENBERG. On the whole we view those facilities as successful. Given budgetary constraints, we have not concluded that we ought to fund yet more regional instrumentation facilities. We are looking hard at the first group funded by NSF to see how successful they have been. The styles of operation of the various facilities have been different. Some have encountered difficulties and delays in getting close coupling with their potential user communities. Others seem to have been quicker off the mark.

Certainly the program has provided facilities in the awkward intermediate range between small instrumentation provided in research grants and major national facilities like Kit Peak.

Senator SCHMITT. Is there any particular type of facility that seems to lend itself best to this arrangement?

Dr. LANGENBERG. In most of those facilities, the core instrumentation tends to come in lumps with an initial cost between $100,000 and a few hundred thousand dollars. And the instrumentation tends to be of the type which can be used relatively widely within a field of science or even across fields of science such as mass spectrometers, very-high-frequency, high-resolution nuclear magnetic resonants, lasers, surface physics and chemistry facilities, OJ spectroscopy, electron defraction and the like. All are usable by a large number, and different kinds of scientists.

Senator SCHMITT. Are they tied in each case to computational facilities?

Dr. LANGENBERG. Not necessarily, no. Many have computing facilities for on-line data acquisition and processing.

Senator SCHMITT. But the product is a tape or something that can be utilized by the researcher in his own institution?

Dr. LANGENBERG. Yes. That can often be the case.

Senator SCHMITT. Are there some where the number crunchers are directly associated with the facility and available for use?

Dr. LANGENBERG. I suspect, since all of these are university-based, that in each case a computational facility is available within the university for use by researchers. In no case is the computational enterprise the central feature of the facility.

Senator SCHMITT. Would you supply for our record a summary of lessons learned so far in this program?

Dr. LANGENBERG. We would be happy to do so.

[The information referred to follows:]

Question. What have been the lessons learned, and what is the potential for expansion of this concept?

Answer. The Regional Instrumentation Facilities concept is still an experimental one and will remain so until the existing facilities are competitively evaluated during the period fiscal year 1982–fiscal year 1984. Nevertheless, a number of les-

sons have already been learned from site visits, annual reports, and comments from the user community. It is a complex matter to initiate and put into operation an effective user facility, and the establishment of the existing facilities has with few exceptions taken longer than initially envisioned. Essential requirements for a successful facility include an active research environment, a dedicated professional staff, and development of and acceptance by the relevant user community. Utilization of the facilities has involved an important and necessary learning process for both management and users as confidence has been built into the concept on both sides. In summary, it is being demonstrated that the concept can be made to work effectively given the proper conditions.

The Regional Instrumentation Facilities are viewed as one element in the spectrum of support for research instrumentation and facilities. Other aspects of instrumentation needs include individual project instrumentation, group or departmental instrumentation, local university facilities, and national user facilities. Within the context of constrained research budgets and the competing requirements of other instrumentation support modes, there is at present inadequate evidence for expanding the regional facilities concept relative to these other modes.

No specific program element for the Regional Instrumentation Facilities appears in the NSF budget for fiscal year 1982 or fiscal year 1983. Continuing commitments to the existing facilities during these years will be met at the originally planned levels using funds provided by the relevant research directorate. Renewal proposals from existing facilities and any new proposals will be considered in competition for regular research funds. As a result, the potential for expansion of the Regional Instrumentation Facilities concept will be determined by how effectively the Regional Instrumentation Facilities are viewed in competition with other support modes on the basis of scientific merit and need.

Senator SCHMITT. What do you believe are the potentials for future expansion should that be possible to do; in what areas you think it would be most profitable to move forward with additional facilities; and also could give us a graphical representation of the location of the facilities for members of the subcommittee.

On research projects, gentlemen, how would the number of research programs supported in 1983 compare with that in 1981 and that anticipated for 1982?

Dr. SLAUGHTER. We will give you precise answers for the record, Senator. Since the inflation rate for research activities at least equals or exceeds the rate reflected in the Consumer Price Index, we would expect to find the numbers of awards to decline slightly. But we certainly can give you the specifics.

[The information referred to follows:]

Question. Compare the numbers of research awards expected for fiscal year 1982 and fiscal year 1983.

Answer. A summary of the numbers of research awards estimated to be granted in fiscal year 1982 and fiscal year 1983 is as follows:

Program activity	Estimate fiscal year 1982	Estimate fiscal year 1983	Difference fiscal year 1983–82
Mathematical and physical sciences	3,167	3,146	−21
Engineering	1,489	1,520	31
Biological, behavioral, and behavioral sciences	3,174	3,085	−89
Astronomical, atmospheric, Earth, and ocean sciences	1,814	1,821	7
U.S. antarctic program	123	148	25
Scientific, technological, and international affairs	756	823	67
Minority institutions science improvement program	0	24	24
Special foreign currency program	340	130	−210
Total, NSF	10,863	10,697	−166

Dr. SLAUGHTER. I have some figures just brought to my attention to illustrate what I have just said. In fiscal year 1981, we made

14,554 awards. The estimated number in fiscal year 1982 will decline to 12,371, and the estimate for fiscal year 1983 is 12,087.

Senator SCHMITT. Do you see any relief as yet due to the steadily declining inflation rate we have seen over the last 12 months?

Dr. SLAUGHTER. The deflators we are using seem to be going down. However, so much of NSF-supported activities depend upon equipment, which has a higher than average inflation. Take fuel, for example, in many of the large-scale experiments, we do not see a decline in that cost.

Senator SCHMITT. And labor costs are not as large a proportion of the project cost as in other activities?

Dr. SLAUGHTER. The percentage increases in labor costs are not so large as in these other areas. We anticipate that the average award size will increase a fair amount in fiscal year 1983 as compared to fiscal year 1982, from about $63,000 to $70,000. The increase will simply take into account the increased costs of doing business for the same amount of research. It amounts to a 10-percent increase in the average award size without a concomitant increase in the amount of research produced.

Dr. LANGENBERG. Labor costs, in most cases, are the majority of the cost in a research project. Since most of NSF-funded research is conducted in universities, it could be said that we have——

Senator SCHMITT. Slave labor?

Dr. LANGENBERG [continuing]. Benefited—and if I may put quotes around that word, from the fact that faculty salaries and graduate student stipends, in general, have not gone up so rapidly as labor costs.

Senator SCHMITT. But it is fun to be a slave in a university.

So basically, we should not anticipate for some time, at least, a reduction in the inflation rate that research is experiencing commensurate with that that we have seen in the Consumer Price Index.

Dr. SLAUGHTER. I think that is correct.

Senator SCHMITT. Now, the Producer Price Index is actually showing a decrease. At least it has for the first time in a long time. Do you expect that to start to appear in some of your costs before long?

Dr. SLAUGHTER. It is hard to anticipate the trends and when they will be recognized. It appears to me that we will be heavily driven by major problems in the conduct of experimental research. Turning that problem around will take a bit longer than the smaller research projects.

It seems to me we will continue to see the cost of doing business in research outstripping the cost of the rest of the economy.

Senator SCHMITT. Is the Office of Management and Budget allowing you to use a higher rate of inflation than your projections?

Dr. SLAUGHTER. No, we are using the Government-wide inflation rate.

Senator SCHMITT. Have you seen any indication they would be willing to do that in the 1984 budget when there is going to be such an obvious disparity between the CPI and the cost of scientific and technological programs?

Dr. LANGENBERG. We have a study under way to see whether we can get an idea of just what the effective inflation rate for this pe-

culiar activity really is. When that study is completed, if it makes a sufficiently strong case, we might develop a research inflation index and persuade OMB to allow us to use it. As Dr. Slaughter pointed out, at the moment NSF is using the OMB inflator.

Senator SCHMITT. Well, I am very curious about this and I hope you will keep the subcommittee informed because in some areas it should be affecting your cost. All the trends and projections are clearly for decreasing cost. Energy costs, at least in fuel, are going down. On the national scale, wage increases have tended to level off, largely in response to decreasing cost-of-living increases, and will probably do so even more this year.

Most goods and services seem to have decreasing rates of inflation, significantly decreasing. So it will be intriguing to learn from you what is holding up the cost of doing basic research.

Dr. SLAUGHTER. We will be happy to provide the results obtained thus far.

[The information referred to follows:]

Question. What is known about the inflation rate of the cost of scientific research? How does this differ from that from more general cost of living increases (e.g., CPI, GNP)?

Answer. There is currently no single measure designed specifically to assess the impact of inflation on the Nation's total R&D performance. There are, however, a number of current studies on the university and industry sectors which indicate that the GNP implicit price deflator or the CPI may understate the effect of inflation on R&D dollars. For example, a pilot study of three large research universities shows that prices of university research inputs have been higher over the last decade than the more general measures of inflation would indicate. A comparison of the various inflation indexes for 1981, using 1967 = 100, shows the university research index at 277 with the GNP implicit price deflator at 243 and the CPI at 263. While the salaries of faculty, graduate students, and research associates, which account for about one-third of the university research total, have increased at rates somewhat lower than the CPI or GNP implicit price deflator, other areas, notably fringe benefits, publications and printing, and occupancy and maintenance costs (fuel, utilities, space rental, etc.), have increased at sharply higher rates.

Recent work by Professor Mansfield of the University of Pennsylvania regarding the industrial sector indicates that wages of support personnel have risen most rapidly with materials and supplies also experiencing relatively high price increases. The salaries of scientists and engineers have had the lowest price increases. In the Mansfield study comparing 1969 and 1979 prices, the inflation index for industry R&D expenditures rose to 194 (1969=100) versus 189 for the GNP implicit price deflator.

Since the results of both the academic and industrial R&D cost studies are based on a small number of case studies, they are suggestive rather than definitive. Until a specific measure can be developed, the present practice of relying on the GNP implicit price deflator appears warranted in view of the relatively small differences between it and other measures being studied.

Question. Would you provide us with an estimate of the additional funding that would be required to:

Raise the number of fellowships to the same level as that in 1981.

Permit funding of the same number of research projects as were supported in 1981.

Provide for a real 20 percent increase in instrumentation and facilities, that would not be at the expense of gains attributed to project support.

Permit funding of the same proportioned of high merit industrial-university cooperative research proposal as are now funded in the MPS and Engineering directorates.

Answer. Careful consideration has been given to setting the levels for the various activities making up the fiscal year 1983 NSF program. Within the bounds of the total request, which reflects the President's knowledge and judgment of the needs and priorities of the entire Federal government, we believe that the efforts described and the corresponding amounts requested, represent a tightly reasoned, well-balanced use of resources by the Foundation. To increase one NSF activity

would, because of a total fixed budget, mean that the funds would necessarily come at the expense of another, thus reducing the inter-program balance carefully thought through in the process of NSF budget development in fiscal year 1983.

Senator SCHMITT. Do interest rates disproportionately influence your costs?

Dr. SLAUGHTER. No; I don't think they do.

Senator SCHMITT. In your university environment, is there some weird situation that causes costs to be affected more by high interest rates then within the economy at large?

Dr. LANGENBERG. I don't see any obvious reason, Senator. I would note that interest on funds borrowed to provide, for example, capital equipment or facilities for research is not an allowable cost in Federal grants. NSF cannot compensate an institution for the interest cost of money borrowed to support research.

Senator SCHMITT. I hope the academic community recognizes and uses their influence wherever they can to change the situation that has developed where short-term interest rates are clearly 10 points now above where they ought to be, based not only on the current rate of inflation, but on all trends that contribute to future anticipated rates of inflation. Ten points; that is a profit that the major financial institutions are gaining on money loaned, over and above what has historically been a reasonable profit.

One has to ask why are they continuing to hold the short-term interest rates up. It is awfully hard to find any logical or technical explanation other than greed, and certainly any influence that the very influential academic community might bring to bear on national financial institutions would be much appreciated by everybody.

That is not your job, but maybe somebody else will read this testimony.

In regard to recipient costs, are the proportions of the total project cost borne by the recipient increasing or decreasing?

Dr. LANGENBERG. As a recipient and as an administrator with a recipient-grantee university, I once tried to estimate the true cost borne by the institution and research supported in part by the Federal Government. It is a nearly impossible task to do with any precision, so it would be almost impossible to say whether that proportion is going up or down.

We do have recent data on the proportion of NSF grants spent for various components: Indirect costs, faculty salaries, graduate student support, supplies, and the like. Those proportions have been stable over the past 5 years or so.

Senator SCHMITT. Can you judge qualitatively the caliber of the marginal research proposal now compared to that of 3 or 4 years ago when more awards were being made?

Dr. SLAUGHTER. We can say safely that the cutoff point is significantly higher quality. Many good proposals receive outstanding recommendations from the peer review process, and we want to support them but cannot. In general, there is an increase in the threshhold level and quality of the proposals able to pass the gate for support.

Senator SCHMITT. Are you developing any contingency plans to increase the number of research projects supported if the current budgetary restraints continue?

Dr. SLAUGHTER. We are looking carefully at cutting back in certain areas and using funds to support more critical areas. From that point of view, yes, we are looking at contingencies and working with the National Science Board to measure the impact of such decisions.

Dr. LANGENBERG. The tendency, however, at the moment, given present and projected future constraints, is in the opposite direction. The tendency is not to increase the number of grants but to decrease the number so that those we fund are funded adequately.

Senator SCHMITT. Is the sentiment of the Science Board and the outside community that if they have to bear cuts, they would rather maintain the grant level rather than spread the money more thinly?

Dr. LANGENBERG. Yes; I believe that to be the case.

Senator SCHMITT. That is not a position of the "haves" discriminating against the "have-nots," is it?

Dr. LANGENBERG. I suppose in part, given human nature, it is; but I don't think it is entirely so. There is a feeling among scientists and engineers whom we rely upon for advice that it is better to make sure that the researchers you can fund are funded so they can do the work. It is better to fund adequately a lesser number of researchers than it is to spread the funds and eventually get to the point where nobody can do any work no matter how good he or she is.

Senator SCHMITT. Has the handoff of lunar sample research from NSF to NASA been completed?

Dr. SLAUGHTER. I think we have worked out an arrangement with NASA such that that no longer creates the researchers' requests and examine the lunar samples. That no longer represents a problem for us. NASA and NSF demonstrate how cooperation has turned out to be an effective way of operating. Probably the example could be a model for relationships NSF has with other agencies.

Senator SCHMITT. Have you heard the same rumors I heard that NASA might consider mothballing the lunar sample territorial facility in Houston?

Dr. SLAUGHTER. I have heard some discussion.

Senator SCHMITT. Have they discussed this with you or your people?

Dr. SLAUGHTER. It may have been discussed at some staff level, but it has not been discussed by senior members of the Foundation with members of NASA.

Dr. LANGENBERG. Senator, I did sit in briefly on an all-day session between our astronomy people and the NASA people in which that was one of many topics discussed, and I think the best thing I can say is that the problem is being worked, and mothballing does not yet appear to be an imminent event.

Senator SCHMITT. Well, I hope rumor is like a Houston cockroach, ugly but easily squashed.

Dr. LANGENBERG. NSF has some interest in the welfare of that facility for reasons other than seeing that scientists have access to the lunar rocks. A considerable collection of meteorites gathered in the Antarctic are also being curated in the Houston facility.

Senator SCHMITT. Excellent. I did not know that, but I should have.

Dr. LANGENBERG. Extraterrestrial material, most likely.

Senator SCHMITT. Sounds like a scientist's judgment. Now, where do you put tectites?

I think we have answered the tectite question, at least based on the last material I had access to.

Finally, Dr. Slaughter, a very parochial interest. Would you please provide the committee with the status of what the NSF is doing with regard to the Sacramento Peak Observatory roads situation? I believe that we had some commitments a few years ago, and I would like an update on this.

Dr. SLAUGHTER. We can provide you a very complete picture of that. There are some activities underway, and rather than trying to treat them cursorily here, we will provide you with very shortly a complete report on the status of that activity. There are some hearings under way to address that. That is a very important issue for that observatory and one that I think we are moving ahead rather well on. So we will get that information to the committee.

[The information referred to follows:]

Question. Please provide an update in the progress of improvements to roads to the Sacramento Peak Observatory.

Answer. Survey crews from the Federal Highway Administration are presently completing the surveys required for the project design. The Highway Administration hopes to have the final design approved by July, 1982. The contract for the first portion of the project (funded by the 1981 and 1982 portion of Forest Highway Funds) could be let in the fall and construction of this phase could be carried out in 1983. The entire project could be completed in 1987 assuming no funding other than the $1,100,000 annually from the Forest Highway fund. New Mexico recently won a Supreme Court ruling which is expected to provide the State with as much as $100,000,000 in additional tax revenue. The 1981 legislature allocated that money to roads. The State Highway Department has said this money will go to road projects presently in their plans, which include the Sunspot road. If this occurs, the road could be completed a year or two earlier than presently planned.

Senator SCHMITT. It is very important because the continued deterioration of that road is making it very difficult to insure the safety of the children of the workers at Sacramento Peak, and I don't think it would save any money in the long run if we finally ended up with a situation where workers had to move somewhere else because of the deterioration of the road.

Dr. SLAUGHTER. The long-delayed public meeting will be held early in May. The design then can be pinned down.

Senator SCHMITT. Do you have any new research results that would be of interest to the subcommittee from the VLA now that it has been in operation for how long, 18 months almost?

Dr. SLAUGHTER. It has been officially in operation since you dedicated it. The best answer is it still far exceeds any expectations, nearly an order of magnitude improvement in the observation precision. And it continues to be a high priority for support from NSF's astronomy division because the scientific community is strongly interested in using it. NSF and the Congress can really feel proud to have put the instrument into place.

Senator SCHMITT. Could you provide for our records some of the factual data, statistical data on the utilization of the facility, both by U.S. institutions and foreign investigators?

Dr. SLAUGHTER. I certainly will.

[The information referred to follows:]

Question. Please provide data on the use to date of the VLA facility by domestic and foreign investigators.

Answer. Proposal pressure on the VLA has been extremely heavy. Requests for observing time are submitted by groups of investigators, some with both foreign and domestic members. The proposals are evaluated for scientific merit by referees, and successful ones are scheduled for observing time on a quarterly basis.

Of the observing projects granted time on the instrument since the commencement of operations, we estimate the breakdown as follows:

Affiliation of investigators	Fiscal year 1980		Fiscal year 1981	
	Number of projects [1]	Percent	Number of projects [1]	Percent
Domestic	152	83	296	84
Foreign	31	17	56	16
Total	183	100	352	100

[1] A project (a scheduled observing session) is broken down by noting the number of investigators with domestic or foreign institutional ties, e.g., a project with 4 investigators (3 domestic, 1 foreign) is counted as ¾ domestic, ¼ foreign.

Senator SCHMITT. These investigators have not yet found any refutation of Einstein's conclusion that the velocity of light is a constant and somewhat of a constraint on interstellar travel?

Dr. SLAUGHTER. No, I don't think that has been found yet.

Senator SCHMITT. There are an awful lot of young people out there that are looking to you all to disprove that.

Dr. SLAUGHTER. I know.

Senator SCHMITT. Thank you, gentlemen. We will have, as I indicated, questions for our record. It has been, I think, a good interchange and we look forward to working with you further in the future.

Dr. SLAUGHTER. We have enjoyed it, Senator. Thank you.

Senator SCHMITT. Thank you very much.

The hearing is recessed.

[Whereupon, at 11:55 a.m. the hearing was concluded.]

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS OF DR. LANGENBERG

Question. Since funding for research instrumentation of faculty at two and four year colleges would now be funded through the research directorates rather than a separate program, how is this level of investment likely to compare with previous years? How well are proposals for this instrumentation likely to compete with research proposals from the major research centers?

Answer. The program will continue to be managed centrally, so that researchers and administrators from these institutions will continue to have on principal point of contact for information, eligibility, mailings, and management. Proposals will continue to be received in competition with each other. The fiscal year 1983 amount will depend on the overall total available for NSF research. Current plans call for it being funded at approproximately the same levels as in fiscal year 1982—about $2 million, which would fund some 100 awards.

Question. How do the different directorates or disciplines differ in the way they handle instrumentation and facilities support?

Answer. Fundamentally, all directorates select from the same set of mechanisms to make needed instrumentation available to the research communities they serve, but apply these mechanisms differently because needs vary across fields.

Support for scientific equipment may be provided as part of the funding of a research project, through an award by a disciplinary equipment program, or through funding of a specialized laboratory or facility Because the scale and complexity of

the equipment depends on the nature of the studies to be conducted, the mix varies from directorate-to-directorate in a manner that responds to the particular needs of the research disciplines for which they are responsible. For example, in the Mathematical and Physical Sciences directorate, the Foundation provides instrumentation and research facilities not only through a project research grant, say in chemistry, but among others, through the Materials Research Laboratories, the Coordinated Experimental Research program in computer science, and the Cornell Electron Storage Ring. Because much research in astronomy and in the ocean sciences requires major, sophisticated facilities and apparatus such as the VLA and oceanographic ships, the Astronomical, Atmospheric and Ocean Sciences directorate provides large amounts of support for national research centers, as compared to other directorates. At the other end of the spectrum, the Biological, Behavioral and Social Sciences provides most of its support for experimental equipment through individual project awards and special instrument programs. Low-cost instruments (i.e., those costing less than $35,000) can be provided to institutions with no or small doctoral programs through a separately-managed competition that makes awards for research equipment in all fields of science and engineering.

Question. The interagency working group plans for fiscal year 1983 are, as you point out, modest. What do you anticipate by way of bolder initiatives for fiscal year 1984 and beyond?

Answer. The Interagency Working Group on University Research Instrumentation is developing a mutiple element approach to the university instrumentation problem. Additional elements will emerge as agencies and the private sector become more aware of the need to modernize university research laboratories and of their opportunities to contribute to meeting these needs. The first step of a government-wide integrated program has been proposed to the Congress in the fiscal year 1983 DOD budget. If the Congress accepts this request, the number, quality, type and cost of proposals received will help understand and quantify needs more precisely. The remaining aspects of the governmentwide program can begin in other agencies when sufficient justification coincides with availability of required resources.

Questions of the Committee and the answers of Drs. Slaughter and Langenberg

Question. In his February 5, 1982, memorandum to the Antarctic policy group, the President pointed out that, "To ensure that the United States antarctic program is not funded at the expense of other National Science Foundation programs, the OMB will provide specific budgetary guidance for the antarctic program."

Couldn't this be assured as well if the non-research support portion of the program budget was left with the Navy or the Coast Guard?

Answer. The separation between research and non-research support is not as clear as it might appear at first. In the fiscal year 1983 budget request $10.1 million of the Operations Support Program is for Direct Science Support. These are costs which in most other Foundation research programs are a prt of the research grants to universities who purchase the support on the open market. There are no indigenous sources of support in Antarctica.

The present responsibility of the Foundation to budget for and manage the entire United States national program in Antarctica has been the subject of three Presidential decisions since 1970, each based on recommendations made after extensive study of the issues involved by the major Executive Branch agencies interested in the U.S. role in Antarctica. As a result of these reviews the point has been made that scientific research is the principal expression of U.S. interest in Antarctica and the national program, including the necessary logistic support, is to be managed and funded by the NSF as a single package.

The General Accounting Office, in a study completed in 1978, concluded there should be no change in the basic roles of the various Federal agencies involved in the U.S. Antarctic Program. This study was undertaken at the request of the Senate Foreign Relations Committee.

During 1979 the Science, Research and Technology Subcommittee of the House Science and Technology Committee conducted oversight hearings of the program with particular reference to the role of DOD in support of the program. No changes in current arrangements were recommended as a result of the hearings.

No significant benefits would accrue from distributing the program costs among several agency budgets. Such a split-up of responsibility would undoubtedly introduce managerial inefficiencies.

Question. Is it true our research presence in the Antarctic region is less resource-development oriented, e.g., krill, minerals, oil, than those of many other nations such as the Japanese and the Russians?

Answer. Practically none of the research being conducted by a dozen different nations in the antarctic region is of a resource development nature. There is, however, research being carried out by most of the nations that is related to resource assessment. Some of the nations such as Japan, New Zealand, and the Federal Republic of Germany, have and are conducting marine geophysical surveys. Also, Japan and the Soviet Union and perhaps other nations are actually harvesting krill for use as fertilizer and as a food for human and animal consumption.

Marine biological research is a large component of the U.S. research program. It is directed toward development of an improved understanding of the structure and function of the vast marine ecosystem in the Antarctic area. Such information will contribute to internationally agreed objectives of equitable and wise use of living natural resources in the antarctic region. Similarly, a large portion of the total program effort is devoted to geology and related disciplines. This work, which enhances our basic understanding of the history and structure of the continent is crucial to the development of international agreement relating to mineral resources.

Question. Is the NSF the proper lead agency to assure our national interests under the Antarctic Treaty or should another more resource-exploration oriented agency have the lead?

Answer. Since the U.S. Antarctic Program is conducted under the aegis of the Antarctic Treaty, the National Science Foundation considers the Department of State as the lead agency in "assuring our national interest." The Foundation funds and manages a national program that is subject to policy oversight and approval by the Antarctic Policy Group which is chaired by the Department of State. Thus, as long as a U.S. basic scientific research program continues to be the principal expression of national interest and policy in Antarctica, the Foundation should continue in its role as program manager. This was the conclusion of the Antarctic Policy Group's detailed study that led to the President's memorandum of February 5, 1982, announcing his decision to have the National Science Foundation continue to budget for and manage the program as a single package.

Question. Provide the names of the members of the National Science Board Commission on Precollege Mathematics, Science and Technoloy.

Answer. The appointment process is still underway and until that is completed, the Foundation does not wish to release the names of the members. It is anticipated that a formal announcement of the membership of the Commission will be made shortly.

Question. When can the OMB guidance be expected, and how is it expected to assure that the President's intentions are met?

Answer. It is anticipated that OMB will provide specific budgetary guidance for the antarctic program during formulation of the National Science Foundation's fiscal year 1984 budget request to the Congress. It is expected that OMB will approve a funding level for the U.S. Antarctic Program that is distinctly separate from the funding levels approved for other Foundation programs. This should assure that the President's intentions are met.

Question. In addition to the specific recommendations for fiscal year 1983 authorization, what, if any legislative proposals is the Foundation suggesting this year?

Answer. The Foundation, at this time, is planning no legislative proposals beyond its fiscal year 1983 authorization.

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF DR. LEWIS M. BRANSCOMB, CHAIRMAN, NATIONAL SCIENCE BOARD

Mr. Chairman and members of the subcommittee, I am Lewis M. Branscomb, Chairman of the National Science Board and Vice President and Chief Scientist of the IBM Corporation.

It is my pleasure to appear before you this afternoon to discuss the role played by the National Science Board in the developoment of the fiscal year 1983 budget for the National Science Foundation, the activities of the Board in rethinking the role of the Foundation in science and engineering education, and the role of both the public and private sectors in providing research instrumentation.

The fiscal year 1983 budget states that Federal responsibility in R&D activities relates both to Federal needs, such as defense, and to national needs, where the Federal Government helps to assure the strength of the economy and the welfare of its citizens. Two main responsibilities in this latter area are (1) providing a climate for technological innovation and productivity growth which in turn encourage private sector R&D investment, and (2) direct research support when there is substantial prospect for significant gain to the Nation, but where the private sector is unlikely to invest adequately.

The second responsibility—direct support of research where the private sector may under-invest—is carried out in many agencies but especially in the programs of the National Science Foundation, where research is supported at the forefront of knowledge across all fields of science and engineering. Our goal is to assure U.S. scientists and engineers broad opportunities for excellence and leadership.

The National Science Board is charged by the Congress with a concern for the health and vitality of America's science and engineering capabilities. Working with the Director's executives and staff, we have spent a large fraction of our time over the past year attempting to balance priorities for NSF's research programs in the face of the very real problems caused by economic conditions and resulting budget stringencies. We are convinced that further advances in science and engineering knowledge and the technical vitality of people with these skills are the cornerstone on which our military and economic security rest. Since we cannot as a country afford to pursue all promising scientific and technical avenues at once, the Board, with the Director as an active participant, has allocated our necessarily limited resources to maximize the return to our scientific capabilities and thereby to the Nation. Let me describe this process.

Last winter and spring, Board members had a series of formal and informal discussions with the Director and Assistant Directors about priorities in the program areas for which they are responsible. These discussions were informed by the flow of advice we get from scientists and engineers in the field—through NSF advisory committees, through meetings and telephone calls, and through our own participation in developments in the various fields with which each of us is conversant. Board members and Foundation staff alike consider it an important part of their jobs to be open to input from the scientific community in a variety of forms, for priority setting in fundamental research is largely a matter of informed good judgment.

The Foundation and the Board must work within the context of overall budgetary policies decided by the Administration and the Congress. Last spring, as you know, the Administration requested changes in several parts of the Foundation's budget, as part of its strategy of reducing the budget in light of the Nation's economic situation. The Board's role in this case was one of assisting the Director by providing policy guidance.

In its policy paper of March 29, 1981 (which I sent to you at that time) the Board agreed that in the short term the National Science Foundation must focus the available resources on the task of contributing as much as possible to the strength of American science and technology; the quality and sufficiency of scientists and engineers educated for careers in research, development, and engineering; and maintenance of the U.S. position as a leader in international scientific and technological endeavors. Thus we put high priority on the key elements of our central mission,

which we conceive to be support of science and engineering research performed primarily in academic environments to optimize both educational and knowledge benefits from a single investment. This priority continues in the proposed FY 1983 budget, and I urge your support of both the level and distribution of that budget. It includes increases for support of scentific and engineering research, thus contributing to NSF's unique role in keeping the sciences strong. It focuses on the educational matrix within which research is performed and future researchers are produced.

Well-trained and highly-motivated scientists and engineers are central to increasing our Nation's potential for growth and increased productivity. The source of these individuals lies ultimately in the primary and secondary education system of this country, and here there is less consensus on the proper role of the Federal Government.

During the past year, the National Science Board considered how the Foundation might carry out its responsibility under the National Science Foundation Act to ". . . recommend and encourage . . . national policies for the promotion of . . . education in the sciences" and ". . . to initiate and support . . . programs to strengthen. . . science education . . . at all levels."

The Board agreed on three appropriate priorities. Highest priority was assigned to research-level education, and this is reflected both in the continued graduate fellowship program in science and engineering education and by the research supported throughout the Foundation, with its intimate connection between graduate education and research. Secondly, the Board agreed that the Foundation should continue to play a role in identifying critical needs in science and engineering education, including needs for which it may not bear the primary responsibility. These activities may encourage other agencies, state and local governments, and private organizations to evaluate and meet those needs. Finally, the Foundation can intervene in selected high-leverage areas where significant improvement in education outcomes is possible with limited investment. The Board asked the Director to generate a plan for implementation of this policy framework and he did so. (Both these documents were sent to you in September.)

One area where the Foundation can play a leadership role, though states and local communities have primary responsibility, is in precollege education in mathematics and science. Many of us in industry are concerned that the future availability of qualified scientists, engineers, and technicians will be jeopardized by the decline in high school enrollments in science and mathematics, and declining quality of such instruction. Although there is an emerging consensus that something must be done to change this situation, there is less consensus about the proper role of the Federal Government, or of the Foundation. Under the circumstances, the Board concluded it must find a way to engage the Nation's scientific community in local activities to establish a stronger base of secondary school graduates with appropriate science, engineering, and math backgrounds from which to draw future generations of scientific and technical people. As a result, at its January meeting the National Science Board approved the establishment of a Commission on Precollege Education in Mathematics, Science, and Technology. We hope to announce the membership of the Commission soon.

The Commission is not just another government commission and will not simply "study" the problems in precollege mathematics and science educations. There have, in fact, been about thirty major studies of the current situation in secondary school education, many of which focus on the specific deterioration of mathematics and science instruction. Just a few of the facts are enough to motivate any citizen to be seriously concerned. Only a third of all high school students ever take in math beyond the tenth grade. A full third of our high schools do not even offer enough mathematics to permit any of their students to gain entry into an engineering college without taking remedial courses, and in fact, about one third of the entrants to engineering colleges do take such remedial courses. Over ninety percent of the states now report shortages of mathematics teachers at the secondary level, and roughly a third of the secondary school science teachers did not themselves major in science.

The contrasting figures for Japan, Russia and Germany (both East and West) are equally staggering. Over a period of time, this difference will surely tell in industrial productivity, perhaps even in our defense posture. It will surely tell in the quality of preparation given our young people for living in a highly technological world.

The National Science Board is initiating the Commission not for the purpose of studying the problem, but to do something about it. The Commission will have about seventeen private citizen members and will be properly supported by staff and expert subpanels. Its duration is planned to be eighteen months.

We hope that major engineering and science professional societies, whose members number in the hundreds of thousands and reach into virtually every school district, will cooperate with the Commission to put their members to work on a grassroots effort to understand and begin to rectify the situation. We expect to come out of the Commission's work with a clear and justifiable role for Federal agencies such as the National Science Foundation, for the private sector, and for citizens everywhere.

Let me now turn to the question of instrumentation. This issue is more important than the contribution to research productivity that modern instrumentation can provide. The fact is that the tools of science and the tools of production are linked by the processes of discovery and innovation, each contributing to the other. Leading edge scientific instrumentation is an essential link in the evolution of new scientific ideas to exploitation of these ideas in the Nation's technology. The National Science Board addressed this point in our policy statement of March 1981, which noted that keeping university equipment at the cutting edge sparks both innovation and productivity improvements in American industry broadly.

Thus, the policy of the Board goes beyond balancing the Federal investment between facilities and talent for research. We seek to keep vital the roots of invention of new instructmentation for science, the rapid development of these ideas by private companies, large and small, and the evolution of the researcher's tools into the design and production tools of industry.

To this end a close collaboration among our university and industrial laboratories is essential. The Economic Recovery Tax Act of 1981 contains two provisions intended to encourage industry to share its instrumentation and knowledge with universities to their mutual benefit.

First, Section 221 of the Act provides a 25 percent tax credit for incremental R&D expenses. The credit equals 25 percent of the amount by which qualified R&D expenses during a year exceed the average of the previous three years. Qualified R&D expenses for in-house research include the wages of researchers and direct support personnel, the cost of supplies, and payments for the lease of equipment. Thus overhead and capital costs are not eligible for the credit (although the company's capital equipment costs may qualify for the investment tax credit). Qualified research expenses for research contracted out are 65 percent of the contract cost, a percentage designed to approximate the ratio of wages, supplies, and leased equipment to the total research cost.

This provision could and should be used by private firms to collaborate with colleges and universities and improve their instrumentation. For example, if a firm sponsored a university research project involving the purchase of a centrifuge, the cost of the centrifuge would be fully deductible as a research expense to the firm. Furthermore, 65 percent of the centrifuge's cost would be included as "qualified research" and would count in computing the amount of incremental research eligible for the 25 percent credit to the firm. Thus, if the centrifuge were part of the firm's incremental research and the firm were in the 46 percent tax bracket, the firm would pay for only 38 cents out of each dollar of the cost of the acquisition of the centrifuge by the university. If the same research were conducted in-house at the same gross expense, the centrifuge would cost the company a net after tax cost of 54 cents out of each dollar, minus the tax benefits of depreciation and investment tax credit. It is probably too soon to tell how much stimulation to private sector research and development investment will result, and how much the universities might share in the growth.

Section 222 can be even more valuable in encouraging firms to assist in updating equipment at colleges and universities. After the passage of Section 222, contributions of equipment to universities entitle the firm to a larger tax deduction if certain conditions are met. For example, if a firm donates a new centrifuge that costs $100 to make and sells for over $300, the tax deduction would be only $100 under the old law but $200 under Section 222.

In order for a firm to receive the increased donation, the gift must be new equipment that is constructed by the firm and given without strings attached to an institution of higher education primarily for research purposes. The firm and the institution must have a written agreement that the equipment will be used in the U.S. for research in the "physical or biological sciences." These conditions also involve some uncertainties that must also be resolved by Treasury regulations. For example, the very term "physical or biological sciences" must be interpreted or extended to include mathematical and engineering sciences at a minimum. The issuance of regulations now being developed that reduce or eliminate uncertainty and guide firms in the proper use of Section 222 will be beneficial to American science and technology.

Many firms are studying ways to use these provisions to improve and update the scientific instrumentation used by our country's colleges and universities, but the extent of their effect is still unknown. Increased private sector support will help, at whatever level it may be available. In addition to the equipment itself, relationships between industry and universities will be strengthened as industry develops an improved appreciation for the talents of universities and university faculty and students learn about interesting research problems important to industry.

The Foundation should and will seek to encourage private companies to expand their participation in university research. These tax provisions will surely help. But we cannot realistically expect the obsolescence problem to be solved in this way alone. We must also encourage the universities to share expensive facilities, to avoid the temptation to under-invest in equipment as a fraction of project cost, and to find innovative ways to capitalize new equipment acquisition with non-Federal funds.

The National Science Board will do everything it can to help the Foundation leverage its resources to assist with needs for research instrumentation and equipment and to promote university-industry cooperation. We are nearing the completion of a Board report on university-industry research relationships that we hope will contribute to understanding and enhance productive interaction between universities and industry. The Board also supports the development of mechanisms by which the Foundation can actively interact with industry in the provision of equipment to universities and colleges and has recently asked its Planning and Policy Committee, in conjunction with the Director, to develop a policy of direct collaboration with potential equipment donors, for future Board consideration and approval. We are excited by the possible new avenues for enhanced collaboration.

I am pleased to have had the opportunity to present these views, Mr. Chairman, and would now like to turn to Dr. Donald Langenberg, who will describe some of the Foundation's recent activities in contributing to improved instrumentation for research performers.

STATEMENT OF JOHN WRIGHT, PRESIDENT, UNIVERSITY OF ALABAMA IN HUNTSVILLE

My name is John Wright and I am President of the University of Alabama in Huntsville, a position I have held for approximately four years. Prior to assuming the presidency at UAH, I serves as the Chief Academic Officer for the West Virginia Board of Regents and Dean of the College of Arts and Sciences at West Virginia University and at Northern Arizona University. In addition to my administrative roles, I have served on the faculty at West Virginia Wesleyan College, Northern Arizona University, and West Virginia University where I held the rank of Professor of Chemistry. I received a Ph. D. degree in Chemistry from the University of Illinois in 1951 and did post-doctoral work at the University of London in 1962 and at the University of Michigan in 1965. I have also worked as a research scientist for seven years in industry and have been a member of the staff at the National Science Foundation. I also have been a member of the Army Science Board.

I am pleased to have the opportunity to submit testimony to this Committee on the fiscal year 1983 National Science Foundation Authorization bill, with particular emphasis on the Science and Engineering Directorate.

I represent 354 member institutions of the American Association of State Colleges and Universities, and am currently Chairman of its Committee on Science and Technology. My testimony is also supported by the following associations: American Association of Cummunity and Junior Colleges; American Council on Education; American Educational Research Association; American Psychological Association; Association for the Advancement of Psychology; Association for Affiliated College and University Offices; Association Of American Colleges; Association of American Universities; Association of Catholic Colleges and Universities; California State University; Council of Graduate Schools; Council of Independent Colleges; National Association of Independent Colleges and Universities; National Association of Schools and Colleges of the United Methodist Church; National Association of State Universities and Land-Grant Colleges; National Council of Teachers of Mathematics; and State University of New York.

Our institutions are located throughout the United States, and include three colleges in New Mexico, one in Arizona, five in Kansas, three in Washington, nine in Wisconsin, nine in Michigan, five in Kentucky, eight in South Carolina, and seven in Alabama.

With a combined enrollment of over 2½ million students, the 354 state colleges and universities of AASCU enroll one out of four of all baccalaureate degree students in the country. Our institutions play a major role in our nation's science effort. AASCU institutions award close to 30 percent of the B.S. degrees in engineer-

ing annually. Many students who ultimately pursue advanced degrees in scientific and technical fields receive their basic undergraduate training at our institutions. A large portion of the nation's future elementary and secondary school science and mathematics teachers ar educated at AASCU colleges and universities. These teachers must be able to communicate the knowledge and skills that will enable our youth to live in an increasingly complex and technology-dependent society.

The past year has been an increasingly bleak and frustrating one for those of us interested in, and concerned with, the future scientific and technological strength of the United States. The Administration's decision to cut funding for all science and engineering education programs, with the exception of the graduate fellowships program, is an example of fiscal considerations—reduced budgets—interfering with perceived national goals—adequate supply of scientific and technological manpower.

For this reason, I urge you to reconsider the Administration's budget request for science and engineering education at the National Science Foundation. As a guideline, I would urge you to adopt at least the level of spending contained in the bill H.R. 5842, recently voted upon by the House Science and Technology Committee. The additional sum of money in H.R. 5842 for science and engineering education, $30 million, is far lower than the actual need, but takes into account current budgetary restraints; the levels in H.R. 5842 are necessary if we are to maintain the vestiges of a national system of science and engineering education and to fulfill the mandate of the Foundation's charter.

THE CHANGING INTERNATIONAL ENVIRONMENT: THREATS TO U.S. TECHNOLOGY

The proposed cutback in funding for science and engineering education comes at the very time in our history when the U.S.'s position of world leadership in science and technology is being severely challenged. The proposed cuts, we believe, ultimately will jeopardize our national security and economic well-being by undermining American industrial, commercial, and military strenghts. D. Allan Bromely, Retiring President of the American Association for the Advancement of Science, recently noted that "to expect scientific and technological progress while abandoning efforts at improving science and technological teaching in our schools is illogical and a disservice to the nation's interests."

The severity of the situation was highlighted in a recent study by SRI International that compared the education and employment of scientists and engineers in the U.S. and the U.S.S.R. Based on its findings the report concludes that "there is a need for concern in the U.S. and that concerns should be manifested in a systematic and comprehensive review of our training of Americans at all levels of education for an increasingly scientific and technological world. Such a review will undoubtedly indicate that changes are required, and we should be prepared to make them . . . If anything less is accepted as a national objective, then there is cause for alarm."

I would like to cite some examples that cause me to be alarmed about our nation's future scientific and technological base.

Manpower shortages in engineering and computer specialists are contributing to the decline in productivity and the decline in U.S. share of world trade. Between 1963 and 1977 productivity increased in the manufacturing industries of the United Kingdom by 51 percent, of West Germany by 114 percent, of Japan by 197 percent, and of the United States by 39 percent. During that same time the U.S. share of world trade in manufactured items declined from 21 to 16 percent, while Japan's share increased from 8 to 15 percent.

The Department of Defense reports that it has problems recruiting and retaining civilian and military engineers; the Air Force reports a shortage of 1,100 engineers in ranks, and a shortfall of 114,000 engineers over the next ten years. It also notes that it is more and more difficult to find officers and NCO's who are qualified to be trained to operate increasingly sophisticated military hardware.

In Japan the number of degrees granted to engineers in recent years has surpassed the number granted in those same years in the U.S. though Japan's population is one-half of ours. The Soviet Union graduates more than twice as many scientists and engineers as does the U.S. and has almost five times as many engineering students. The U.S. ranks third behind the Soviet Union and Japan in the proportion of engineering graduates in the population.

About 1.4 million scientists and engineers will be needed to fill growth and replacement demands by 1990.

By 1990 half of the workers in any factory may well be engineers and technicians; most of them will require massive retraining.

Against this ominous background, our nation's science and engineering education establishment is beset by a range of problems. This Committee is all too familiar

with the litany—shortages of math and science teachers in elementary and secondary schools, as indicated in the data presented by the National Science Teachers Association, inadequate laboratory facilities in colleges, lack of research experiences for undergraduate students, rising undergraduate engineering enrollments coupled with shortages of engineering faculty. You, as well as I, know that our system of science and engineering education is in a state of crisis. What we lack however, is a nationwide commitment and agenda to deal with these problems.

THE ROLE OF THE NATIONAL SCIENCE FOUNDATION

I strongly believe that the National Science Foundation must play a leading role in restoring the health of American science and engineering education.

When the National Science Foundation was established in 1950, it was authorized and directed to "initiate and support basic scientific research and programs . . . and science education programs at all levels." The educational mandate of the National Science Foundation has been an integral part of our nation's scientific establishment since that time. It was clearly reaffirmed when Congress in 1979 rejected proposals to move the science education programs out of the National Science Foundation to the newly created Department of Education.

Now in 1982, this dual mission of the Foundation is being abrogated with the Administration's proposals to significantly reduce all education programs. The higher education community, collectively and individually, testified last year before various Congressional committees urging the rejection of the Administration's plan as a shortsighted and strategic error. We believe that the reasons for the Foundation's charter in science and engineering education remain as valid today as they did in 1950 and that adequate funding for science and engineering education must continue.

We were somewhat encouraged last year by Congressional decisions that restored limited amounts of funds for the National Science Foundation to conduct the education programs that are mandated in its charter. The need for science and engineering education programs is great, yet the monetary resources available this year (a little over $20 million) will be disproportionate to that need. I urge Congress to once again reject the Administration's fiscal year 1983 plan to eliminate all science and education programs, except fellowships, and to provide funding for a range of education activities at the Foundation.

What role should the National Science Foundation play in correcting the disparity between available resources and perceived needs? One approach would be for a clear and unequivocal call for increased funding of science and engineering education programs. Such a call coming from an eminent group of scientists would serve to dramatize the problems at hand and the range of solutions necessary to deal with them.

In contrast, however, the Foundation has proposed the establishment of a Special Commission on Science and Engineering Education. For the record, I would like to introduce a letter written by Allan W. Ostar to the NSF expressing our concerns with this approach.

We do not need a Commission to study a problem, the dimensions of which are already clear. We should not wait 18 months for this Commission to make its recommendations. We need action by Congress now so that American science and engineering education may be restored to a system of excellence. We need a Congress that will take this action and support science and engineering education in our schools, colleges and universities with adequate levels of funding.

THE REDUCTION OF SCIENCE AND ENGINEERING EDUCATION FUNDING: ITS EFFECT

What will be the likely long-term effect on our nation if the science and engineering education programs of the National Science Foundation are eliminated?

First, the size of the pool from which future scientists and engineers will be drawn will be severely reduced. By 1995 the proportion of the total population in the 81-24 age range will be 25 percent less than it was in 1980. If, as we approach the end of this century, the number of scientists and engineers is not to decrease in absolute terms—let alone increase to meet what by then will be an increasing industrial and military demand—the proportion of this population prepared for higher education in science and engineering must increase. But if federal science career motivation programs are cut off, we can expect a smaller proportion, and hence a smaller number of young children to be attracted to science and engineering careers.

Many of those children who do become interested in science when very young will be turned away by the poor quality of science teaching they encounter in their

junior and senior high schools. Without federal help science and mathematics teaching will be unable to keep current with new developments. Without federally funded in-service institutes high school science and mathematics teachers will fall further behind in their subjects, and their already damaging isolation from ongoing contact with research and the real world of science will be made more complete. Without federal assistance colleges and universities will be unable to upgrade instructional laboratory equipment, introduce important new scientific and educational concepts to undergraduates and, in general, improve the quality and effectiveness of undergraduate science education. Every year this persists will be a year that hastens the increasing shortfall of scientific human resources.

Second, new entrants into the nation's technical and managerial work force will, in the aggregate, be increasingly underprepared to function effectively. Even now the schools are failing to turn out graduates who can cope with the increasingly technical nature of work in commerce, industry, and the military. To allow the situation to become still worse by withdrawing the only federal effort that addresses the educational roots of our productivity/security concerns, is to incur enormous national (if not federal) costs. Each year that the system fails, the "educational national debt" grows, ultimately to be paid by the public. Industry and the military must provide science and mathematics education to make up for school failures. To the extent that our business and defense establishments are unable to rectify previous science education failures, productivity lags further, inflation worsens, public costs soar. The effect is cumulative. Each year that we let this problem go unattended by national leadership and resources, we mortgage the economy, and face the unhappy, totally unnecessary prospect in a few years of either investing in expensive "reeducation" or paying the price of ill-prepared workers year after year.

If the federal role in education is now diminished virtually eliminating NSF involvement, then there is little chance of turning things around. The price we will pay—in terms of scientific career development and a technically competent workforce will be out of proportion to the money saved.

The present crisis presents the best opportunity that has existed in several years to refocus and sharpen the NSF effort. However, it would be unwise, and inefficient, to phase out all NSF science and engineering activities while this reconceptualization is taking place. Momentum would be lost, valuable programs interrupted, talent dispersed, and attention diverted to the logistics of phasing out the budget, facilities and personnel of a doomed enterprise. In this regard, the recent reorganization of the Science and Engineering Education Directorate into an Office of Scientific and Engineering Personnel and Education is particularly regrettable.

Science education at NSF must be strengthened so that it can be restored as a more effective partner in sharing with state and local agencies and public and private institutions the responsibility for, and costs of, putting science education back on its feet in this country and keeping it there. In order to achieve such a revitalization it will be important for certain problems to be dealt with thoughtfully and imaginatively by the NSF, the National Science Board, OMB, and Congress.

In this regard, the House Committee on Science and Technology has asked NSF to submit its plans for a revitalized science and engineering program to it by October 15, 1982. Though we are opposed to any delays, I would hope that your Committee will also ask for such a plan within this timetable so that the agency might proceed with improvements in our nation's science and engineering education system.

Recently, AASCU surveyed its membership to learn how science and engineering education cuts would affect course offerings in these areas. I include for your information in the attached appendix a summary of these comments. Without an exception, the institutions agreed that it would be extremely difficult to continue to offer those science and engineering education courses that had been previously supported by NSF.

I would like to give you two examples here of how small amounts of money have benefitted our institutions. Similar benefits have also been reported by our nation's private colleges and universities.

$20,000 to Ferris State College in Big Rapids, Michigan will be used to refurbish physiographic equipment already on hand for use in biology courses. Refurbishment, in this case, rather than replacement will lead to substantial improvements in instruction at a savings over the cost of new equipment. It should be noted that the institution is required to match the $20,000 NSF contribution.

$25,745 to Ball State University in Muncie, Indiana will be used to develop a course for non-science majors in using scientific information for formulating opinions on complex technical public policy issues, such as the use of nuclear fission in commercial power generation. Again, the institution must acquire further support from other sources to supplement the NSF award.

I thank you for the opportunity to present this testimony to you. I would be pleased to respond to any questions that you might have.

STATEMENT OF THE ASSOCIATION OF AMERICAN COLLEGES

The Association of American Colleges is pleased to submit to the Senate Commerce, Science and Transportation Committee a statement of our position regarding the 1983 authorization bill for the National Science Foundation. AAC represents nearly 600 higher education institutions, both two and four year, public and private, which are committed to the enhancement and improvement of liberal education. As both science and mathematics education are integral to a liberal education, AAC's members find issues before you today of primary concern. They are particularly interested in the authorization for funding of the Directorate for Science and Engineering Education.

The cutbacks in funding for science and engineering education as proposed by the Administration come at a time in our nation's history when our position of world leadership in science and technology is threatened. Shortages of engineering and scientific manpower both contribute to the weakening of our industrial productivity and to the shortages of technologically trained personnel reported by the Department of Defense within the ranks of our armed forces. In the long term it is illogical to expect scientific research and technological innovation to flourish without sound basic education in science and technology for young men and women who will become the scientists and engineers for tomorrow. Manpower shortages will not be overcome by support for research alone, but will be remedied only through improvement of scientific and technological education.

Beyond the national security and economic considerations, there are broader concerns for the future of our country. In 1959, the President's Science Advisory Committee cautioned that a democratic society cannot conduct its affairs amid prevailing popular ignorance of science and technology. In the words of the committee:

"Science affects the life of every contemporary man every day. It conditions decisions that need to be made by government on many matters, including national defense, foreign policy, and public health. It affects the decisions made by individuals on business problems, on selecting a community in which to live, on choosing an automobile, a record player, or perhaps even a dentifrice. If an individual is ignorant of science he must guess what to do or else believe what he is told. Even if he is told what to do by an expert, he has no way to check on this advice or even to understand it. This unhappy predicament is precisely that of most citizens of the United States today. Their fate in important matters and trivial matters alike may thus be decided without their participation. And it will not be otherwise so long as they remain ignorant about science and technology."

The committee went on to quote Alfred North Whitehead's admonition that advance in science is absolute, that unprepared societies which do not keep pace with it are doomed. Without widespread public understanding and support, the committee warned, that effort could not be consistently maintained. Indeed, the very essence of our culture and society is being determined by scientific progress and technological change, and all participants in our democratic decisionmaking process are becoming increasingly dependent on technical and scientific knowledge. Education in science and technology is waning at the very moment when the need for knowledge of scientific principles and technology is ever greater for those wishing to exert leadership. Unless all of our citizens, not just scientists and engineers, master the new technologies, the new technologies may very well master them.

Our problems and concerns are national in scope and will require strong national leadership. The National Science Foundation was founded and authorized in 1950 to "initiate and support basic scientific research and science education programs at all levels." Since that time, strong educational programs at the elementary and secondary, undergraduate, and graduate levels have been developed, implemented and operated. Our existing situation now demands leadership from NSF in science education, and this requires adequate support. We should not, at the first sign of financial difficulties, abandon long-standing policies and programs.

In light of these concerns, AAC respectfully urges this Committee to carefully consider the budget for science and engineering education at the National Science Foundation, and to adopt as a minimum the $45 million funding level recently approved by the House Science and Technology Committee for science education programs. This, we believe, represents the rock bottom amount necessary for continuation of the requirements of NSF's charter.

As evidence of its concern for science education, the membership of the AAC passed the following resolution at its 1982 annual meeting.

RESOLUTION ON SCIENCE EDUCATION

Whereas leadership in scientific research which is fundamental to improved economic productivity and national security depends on adequate basic education in the sciences;

Whereas science education is an integral part of liberal education as well as being an essential prerequisite for a technically-competent and scientifically-oriented work force;

Whereas both the extent and quality of science education in the nation's schools and colleges have seriously declined; and

Whereas withdrawal of federal funds from support of science education will further impair the quality of science education and threaten deterioration in the quality of basic research and national productivity and security; therefore, be it

Resolved—

That the President of the Association of American Colleges and its Board of Directors, in efforts supportive of basic research and science education, strongly support adequate funding of science education and, in particular, oppose further reductions in the federal commitment to science education;

That the President of the Association work with officers of other educational associations to urge reconsideration by the Administration of the decision to eliminate federal involvement in science education; and

That the President of the Association convey this resolution at a timely moment to the chairmen of the appropriate committees of the Senate and the House of Representatives of the U.S. Congress.

STATEMENT OF ARTHUR C. GENTILE, PH.D., EXECUTIVE DIRECTOR, AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES

Mr. Chairman and Members of the Committee, I am grateful for the opportunity to present the views of the American Institute of Biological Sciences on the fiscal year 1983 budget for the National Science Foundation (NSF) to this Committee. The Institute is a consortium of thirty-eight professional societies in biology with an aggregate membership of over 60,000 scientists. Since the vast majority of these scientists are at universities and colleges and are engaged in basic research and since the major source of support for this research is the NSF, we have a long-standing and continued interest in all legislation which impacts upon the Foundation.

We were pleased to hear Dr. Keyworth's statement before the House Committee on Science and Technology where he reaffirmed the administration's support for funding basic research. He stated "Support of science and technology—especially basic research—is a long-term investment that represents an essential element in the foundation of a healthy economy". However, his statement that the growth that science and technology have enjoyed for so many years cannot continue in a period of fiscal austerity may be challenged. In a report of the National Science Board (Science Indicators, 1980) it is shown that federal support for all R. & D. has shown essentially no increase in constant dollars since 1968. Civilian R. & D. as a percent of the GNP has increased only 10 percent in the U.S. during the past fourteen years, while in West Germany it rose 30 percent and in Japan it rose 35 percent. These figures are reflected in the differences in manufacturing productivity among the three nations. Basic research, which amounted to only 15 percent of the R. & D. budget in 1981, is most vulnerable to budget reductions, while at the same time it is the source of some of the most unexpected and dramatic technological gains. In biology, for example, the results of research in genetic engineering, have resulted in impressive technological gains, and this field is only in its infancy.

Research in biology represents some of the most rapidly advancing areas in science today. These include studies on biological systems which may be used to address major problems in health and agriculture, as well as provide answers to the prevention of the further deterioration of our environment. It is therefore, gratifying that the proposed NSF budget for fiscal year 1983 for research in the biological sciences shows a 6.1 percent increase over the current year. However, this increase is not a real one even if one accepts the administration's estimate of inflation in 1983 of 6.5 percent, a figure which may prove to be highly optimistic.

If, on the other hand, we should be grateful for small blessings in this era of ever-decreasing budgets, as has been suggested, it might be well to concentrate on specific areas of the NSF budget which require your attention. Science education appears

to have been targeted for extinction by the current administration. Science education, which had an actual budget of $71 million in fiscal 1981, is budgeted for $21 million in fiscal year 1982 (including funds restored by the Congress). For fiscal year 1983 the administration requested only $15 million, an amount which maintains the NSF Graduate Fellowship program but eliminates all other educational activities. We were pleased to see the authorization for science education increased to $45 million by the House Committee on Science and Technology, and urge you to endorse this level of support.

It is well documented that science, mathematics and technological education in the United States, both at the secondary and college levels, is in a precarious decline. Entering freshmen in college have shown, by national test scores, a severe deterioration in mathematical and academic skills. What makes this deterioration so frightening is that the future economic and physical welfare of our citizens, as well as our future national security is dependent upon a supply of highly trained scientists and engineers. The United States is losing the technological edge it once enjoyed over other countries around the world, and the lead time to correct this precipitous decline is running out. Countries such as Japan, USSR, and West Germany have built into their educational systems a heavy emphasis on science and mathematics. Japan produces more engineers per capita then the United States; the conclusion is obvious.

The current crisis in science and engineering education is the result of many factors, including the attitudes of parents, society, and students, as well as an absence of national direction. The appointment of a special commission to advise the President on science education is a step in the right direction. Its recommendation, however, will not be forthcoming for some time. In the interim we should not abandon our modest efforts to improve science education by eliminating its budgetary support. If we do, we shall face increasing difficulties in securing talented and highly trained minds for the scientific disciplines in the future.

Another facet of science education is to promote public understanding. Indeed, the increase in the number of popular science magazines and the success of television science programs indicate that the public is not only supportive of science education, but thirsty for a knowledge of science. If the public is being asked to support science and all its ramifications, it should be provided an opportunity to learn what science is doing, how it is being done, and why. To the average American, science has become too arcane, and this condition must be remedied if we are to expect popular support for scientific endeavors.

The problem of modernizing research equipment and research laboratories is another that is not addressed in the fiscal year 1983 budget request. In the biological sciences, the current budget calls for $5.2 million for biological instrumentation, an increase of $0.9 million over the current level of support. These funds will be used to support the cost of purchasing instruments needed for specific research projects on NSF grants. The program proposed by the NSF to modernize research facilities did not survive the budget process for fiscal year 1982, although the Senate Committee on Labor and Human Resources did authorize $14.5 million for this program.

In the U.S., most basic research is conducted in university laboratories. Modern research is highly specialized and sophisticated and requires equally sophisticated and expensive instrumentation. Over the last fifteen years, funds for instrumentation have been severely curtailed and today, university laboratories fare poorly in comparison to their counterparts in government and industry. The deterioration of university instrumentation is threatening the capacity of even the best institutions to conduct research and provide quality training. The lack of state-of-the-art instrumentation and attempted use of obsolete, frequently malfunctioning instruments are bound to impede research efforts. In addition to instrumentation needs, research programs cannot operate at full capacity without adequate facilities, such as laboratories, animal facilities, and greenhouses. Many of these facilities were built when universities were expanding during the 1950's and 1960's and are becoming old, while replacement and renovation funds are difficult to obtain from other sources. We urge you to give careful consideration to this need.

Statement of the American Educational Research Association

The United States is a first-rate intellectual, political, industrial, and military power. The national government of such a country dare not abdicate its responsibilities to provide the essential education needed to retain its international position. The symbolic effect of the administration's plans for NSF science, engineering, and mathematics education are damaging enough. The Congress must act with dispatch

to correct this impression of neglect and restore substantive efforts to strengthen the mindpower of America's future.

The Administration's budget for NSF science education and the decision to abolish the NSF Science and Engineering Education Directorate is both beyond understanding and, taken with other cuts in education programs, apparently mindless. The programs of the SEE Directorate were (and can be) particularly focused on several of the most salient problems of American education: (1) a shortage of math and science teachers, (2) instructional problems in math and science at the pre-college level, and (3) personnel and instrumental constraints on the ability of higher education to prepare the next generation of scientists, engineers, and mathematicians. If ever there was a need of national leadership by the federal government in the area of science education, the time is now. NSF, instead, has formed a commission to study the problem. Over the past several years, the National Academy of Science, NSF and the Department of Education, and comparative studies of the United States, Japan, Germany, and the Soviet Union have already documented the problem. A new NSF commission may be useful in identifying areas of collaboration between schools, colleges, government, business, industry and others in the private sector; however, it is no substitute for a focused set of essential science education programs.

The fiscal year 1982 administration budget and congressional appropriations all but eliminated the most promising programs in NSF science education. The Administration has proposed another 25 percent in Education Department (ED) programs, on top of the 15 percent already imposed; ED will not take up programs eliminated in NSF. It is not too late for the Congress to take the leadership in mandating that NSF provide programmatic support in three essential and productive S.E.E. areas.

I. A PROGRAM OF RESEARCH AND ANALYSIS IN SCIENCE AND MATHEMATICS EDUCATION

This program would focus on the improvement of pre-college math and science instruction. One of the most promising programs of S.E.E. was the research in science education (RISE) program. The RISE effort, on hold but not destroyed, is essential if math and science courses, particularly at the jr. and sr. high school levels, are to effectively increase math and science literacy. The RISE program cannot be supported by the ED's National Institute of Education which has a frozen spending authority (fiscal year 1982–84) −25 percent below fiscal year 1980 and a current appropriation −28 percent below its original fiscal year 1981 allocation. Work in progress, and greatly threatened by the Administration's proposals, include the following:

Cognitive science applied to problem solving, physics instruction, mathematics learning, etc.: Work at the University of Pittsburgh, Carnegie-Mellon University, and University of Massachusetts at Amherst is focusing on a variety of student learning challenges—e.g., learning from error, unlearning incorrect problem-solving strategies, anxieties about math and science courses, etc.

Computer literacy: Use of microprocessors in secondary school mathematics and science courses has been studied to determine effective ways to introduce students to computers and provide them the essential technological understandings to prepare them for careers or advanced education.

Learning technologies and teacher shortages: A recent nation-wide study of teaching shortages reported that 34 states have shortages of "severe shortages" in mathematics teachers, and over 40 states have severe shortages in physics teachers in our schools. Studies must focus on ways to expand the human resources that we do have in these areas and explorations were underway in the use of computer assisted instruction for critical math and science courses.

Mathematics teaching strategies: School mathematics, with a mandated emphasis on "basics", has been successful in improving computation skills. Research studies have identified the problems associated with declines in math test scores at the jr. high level. Schools have neglected instruction in the development of problem solving skills. S.E.E. studies are showing how teachers can use the familiar to improve conceptual thinking and problem solving.

Literacy and science learning: Research studies at Michigan State University and the University of Georgia have focused on students' ability to comprehend from text and to translate what is read into scientific concepts. These studies are leading to modifications in school and college science and math text books.

Mathematics literacy and improved thinking and instruction: Studies on 9th grade mathematics learning have identified concepts which are essential to mathematics learning. Studies have discovered learning problems with inferential thinking and approaches to mathematics problem solving. New instructional strategies

are being developed to assure that students have the essential "mathematics literacy" tools.

Three points need to be made concerning the need to revitalize the research/analysis program in the S.E.E. Directorate:

(1) No other level of government will support such studies and drastic reductions in other education R&D programs and the social and behavioral sciences in NSF make it unlikely that other parts of the federal government will focus on these critical teaching and learning problems.

(2) It is essential that a continuous assessment of the status of math and science education is known and S.E.E. has the ability to provide such assessment.

(3) There is a danger that educators and scientists may move ahead in instructional development and education software ("courseware") programs without the needed understanding of real classrooms and student learning abilities, developments, and problems. This was done in the 1960s and resulted in little used equipment, poorly prepared teachers, and curricula inappropriate for actual school and college classrooms.

II. A PROGRAM OF STAFF DEVELOPMENT AND SUMMER INSTITUTES FOR MATH AND SCIENCE TEACHERS

There are cost-effective ways to reach practicing math and science teachers. Summer institutes, staff development programs administered by science and mathematics teaching organizations, and collaborative efforts with teacher education institutions, state education agencies, and technical assistance organizations can be employed to bring important information and teaching strategies to practicing educators at the pre-college level.

III. HIGHER EDUCATION PROGRAMS FOR UNDERGRADUATE AND GRADUATE STUDENTS

The remaining S.E.E. funds have been almost exclusively devoted to graduate fellowships. The Congress should take this opportunity to direct limited funds to a more favorable balance between graduate and undergraduate education. In addition to fellowships, NSF should focus on the needs of undergraduate science and engineering education: laboratories, equipment, instruction, and faculty retention.

THE NEED TO MANDATE A PLAN FOR THE FUTURE

It is recognized that, in the short run, the fiscal year 1983 program for S.E.E. must be focused on the above areas of most pressing need. Even when so targeted, we understand that only limited (about $50 million) will be allocated for fiscal year 1983. It is, therefore, essential that the Congress mandate that the National Science Foundation, in collaboration with the science, mathematics, and engineering communities, present a plan for a national program to address problems in science education. The plan should be specifically addressed to pre-college instruction, the math and science teaching force, R&D in math and science education, undergraduate and graduate math, science and engineering education as they relate to: Scientific and mathematical literacy; innovation and development in the private sector; technological literacy in the workforce; military personnel and the specific industrial capacity to deliver essential military equipment (including the potential drain on the nonmilitary innovation, development, and production); international trade and economic revitalization.

The plan should also include a programmatic plan for the S.E.E. Directorate with an appropriate budget request for fiscal year 1984 and the years beyond.

MARTIN MARIETTA AEROSPACE,
New Orleans, La., February 12, 1982.

Dr. JOHN B. SLAUGHTER,
Director, National Science Foundation,
Washington, D.C.

DEAR DR. SLAUGHTER: I am pleased to have this opportunity to make you aware of the role NSF has indirectly played in the Space Shuttle, External Tank Producibility Program.

Recently we have honored two members of the Polymer Processing Program of MIT, Dr. Lewis Erwin and John McCree, a graduate student in Mechanical Engineering, for their contribution in the development of a new molding process for our Super Lightweight Ablater (SLA). This new technique, which will replace the costly handpacking/machining method, could save about $100,000 per External Tank.

Since NASA plans to produce one tank for the more than 400 Shuttle flights scheduled through the next decade the savings to the U.S. taxpayers could reach in excess of $40 million.

The MIT-Industry Polymer Processing Program is the cooperative research effort between MIT and American Industrial firms that was founded in 1973 with "seed funds" provided by NSF through its Experimental R&D Incentive Program, now under the auspices of your Industrial Science and Technological Innovation Division.

I think if you examine the intent of the Cooperative Research Center Program and our Producibility Program, you will agree with its success; especially in light of the dollars spent in 1973 on the ROI manifold and the significant cost reduction anticipated today with the External Tank Program.

I am enclosing a copy of the news release Martin Marietta distributed nationally on January 28, 1982. If you have any questions concerning details of this innovative process, please feel free to contact me at NASA's Michoud Assembly Facility, New Orleans, Louisiana by dialing (504) 255-3700.

Sincerely,

R. M. DAVIS.

Enclosures.

NEW INSULATION METHODS SAVE SHUTTLE TANK PRODUCTION COSTS

New methods of applying insulation to components of the Space Shuttle's external fuel tanks will result in substnatial cost savings during the next 10-15 years of the Shuttle program, officials of Martin Marietta Aerospace have announced.

Martin Marietta recently honored two researchers from the Massachusetts Institute of Technology (MIT) who worked with the company to develop one of two new cost saving methods of insulating components of the Shuttle's external fuel tanks.

Dr. Lewis Erwin, du Pont associate professor of Mechanical Engineering at MIT, and John O. McCree, a graduate student in Mechanical Engineering worked with Martin Marietta to develop an efficient vented compression molding technique of applying insulation to tank parts. Using the new methods, insulation material will be molded onto components rather than hand applied as it is now.

These new techniques could save about $100,000 per tank said Saul R. Locke, manager of productivity for Martin Marietta's Michoud division in New Orleans where the company manufactures the external tanks. Since the external tank is the only major non reusable element of the Shuttle, Martin Marietta will make one tank for each of the more than 400 Shuttle Flights NASA has scheduled through the Mid-1990's. Savings accomplished by useing these two insulation techniques could reach $40 million on that quantity of tanks and on that schedule.

The insulation, which is the consistency of wet beach sand, is currently hand packed onto tank components. After the material dries, it is machined to exacting shapes. "Since several hundred components must be insulated for each tank, this has been an expensive and time consuming process," Locke said.

With the new technique developed by the MIT researchers, a tank part is placed into a mold which is then filled with insulation. A wire screen of precisely determined mesh, formed to the shape of the final product, is then pressed onto the surface of the insulation material. As the material is compacted, the excess is forced out through the openings in the screen. The material that remains is uniformly compacted and matches the shape of the mold. The screen and the excess material are then removed and replaced by a conventional compression molding surface which smoothes the roughness left by the screen and applies pressure while the resins in the insulation cure.

The development of this cost saving technique was the result of MIT and Martin Marietta cooperative research as part of the MIT-Industry Polymer Processing program in MIT's Laboratory for Manufacturing and Productivity. The Polymer Processing program was founded in 1973 with the seed fund provided by the National Science Foundation's Experimental Research and Development Incentives program. This program's objectives are to help American industry increase productivity and to improve the United States' technological base by transferring technology from universities to industry.

A second important cost saving method of applying the insulation was developed by Martin Marietta's Advanced Manufacturing Laboratory in New Orleans. Parts to be insulated are put into a mold, then the insulation is gas injected through a tube into the mold. The mold is removed after the material cures.

Martin Marietta manufactures the Shuttle's external tanks under contract to NASA's Marshall Space Flight Center, Huntsville, Alabama.

FUSION ENERGY FOUNDATIONS,
New York, N.Y., April 24, 1982.

Senator HARRISON H. SCHMITT,
U.S. Senate, Chairman, Subcommittee on Science, Technology and Space, Washington, D.C.

DEAR SENATOR SCHMITT: The Fusion Energy Foundation wishes to submit the following testimony on the fiscal year 1983 authorization for the National Science Foundation to your subcommittee on Science, Technology and Space. As per the directions of your letter to me dated April 12, 1982, I have mailed this testimony to Dr. Dennis Barnes, Chief Scientist, Subcommittee on Science, Technology and Space before April 26 in order to assure that our testimony will be incorporated in the printed record.

TESTIMONY

While the National Science Foundation (NSF) is not the sole agency for funding science research and all that entails, it is responsible in a major way for the development of scientific manpower. The Fusion Energy Foundation therefore recommends not less than $500 million for the fiscal year 1983 authorization to be spent on teacher-training, the development of advanced curriculums and equipment for laboratories—in all the areas of science, engineering, and mathematics in order to guarantee a high technology future.

Let the definition of "high technology" however, be unequivocally clear. The funding and training of scientists, mathematicians, and engineers must be done to train them for an economy which is fission-fusion energy directed, a space program which is geared to rapid colonization of near-earth space and probes for advanced cosmological knowledge and a nuclear science military program based on the development of E-beams. Unless that is done, the U.S. will never be a strong nation able to compete in any economic market with Japan, West Germany or the Soviet Union.

There is an attempt afoot, instead, to define a U.S. program of high technology as merely the electronics industry or "information transfer" fields! Make no mistake about it, other nations like Japan and the Soviet Union are training scientists, engineers, mathematicians, and skilled workers to be able to function in a strong industrial economy overall—an industrial economy which will be the underpinning for their space programs, fusion-fission economies and advanced weapon systems. Electronics and information transfer will merely service those areas.

Increased NSF funding should be applied immediately to turn around the devastating shortages and degenerated curriculums in the following particular areas.

(1) Teacher-training in advanced curriculums for primary and high school math and science courses. It's commonly known now that even if high school students wanted to enter college programs in science, engineering or math, they actually can't because they're not prepared. No wonder that's the case when you consider, for example, that last year the universities of Ohio State, Nebraska and Minnesota each graduated only one newly qualified math teacher. Statistics in other states like California and Connecticut for math and science teachers are equally alarming.

(2) Training Ph.D candidates in the sciences and engineering and math. According to Yale's president, Professor Bromley, in just 9 years from 1980, Ph.D degrees granted in all major science, math, and engineering catagories, but especially physics and astronomy—dropped 50 percent!

(3) Establishing some 100 national science research centers which we recommend be spread throughout the U.S. Those centers must be focused on the crucial "science driver" frontier areas of plasma physics for fusion energy development, relativistic beam applications for both military science and resource chemistry, and high energy physics more broadly, with related work in biological science. This task oriented work will pace science research and revive science teaching. Currently ill-prepared and intellectually depressed teachers as well as new potential teachers at the primary and high school level could get beefed up in their fields and do so by mixing with the college people working on a broad range of science, math,, and engineering projects at those centers.

(4) Training youth to be skilled technicians in many fields associated with the development of advanced nuclear energy systems, NASA projects and military projects. The lack of skilled technicians in the labor force is as serious as the lack of the scientists, engineers and mathematicians in that same labor force.

(5) Educating foreign students in the fields of science, math, and engineering on a fair and equal basis should get strong support from NSF funding. Only in a developed world can U.S. leadership in science and industry have any lasting value or purpose.

(6) Ending funding for education school courses like "educational psychology." As a matter of fact, some NSF money should be spent on doing a study which demonstrates that the useless, Deweyite education courses that have taken over U.S. education schools are in fact the cause of teachers graduating with too little background in science and math. Science and math teachers should receive NSF money to beef up their courses in science and math or engineering.

We are currently working on requirements to define the number of scientists, engineers and mathematicians necessary to fulfill the needs of our proposed high technology development program. The Fusion Energy Foundation will be pleased to offer whatever assistance we can in the area of advanced curriculum development in the fields of physics, math, biology, astrophysics, fission, fusion and E-beam development.

Respectfully submitted.

MARY GILBERTSON.

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